A REVISION OF THE GENUS *ACARUS* L., 1758 (ACARIDAE, ACARINA)

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CONTENTS

1. INTRODUCTION

Linnaeus (1758) included thirty-one species in his genus *Acarus*, most of which were mites. These species are now represented in four sub-orders of the Acarina and the genus is restricted so that only one of them, the "Flour mite", is included in *Acarus*.

This species, which is the most serious of all the mite pests of stored food products has been considered to be very variable, the variation indicating no more than racial differences. Two kinds of hypopi have been attributed to it and it has been recorded both in stored product and out-door habitats.

This paper summarises the taxonomic conclusions of a study made to test the hypothesis that these attributes possibly reflected differences between sibling species rather than racial variation within the " Flour mite ". Biological conclusions relating to hybridization between and hypopus formation within populations will be published elsewhere.

In the text, generic and specific headings are followed by a list of synonymies *sensu stricto*. A second list of abbreviated references is given at the end of certain specific descriptions ; these are classified as published descriptions or as misidentifications attributable to a particular species. Full bibliographic references for these synonymies *sensu lato* can be found in Appendix I which lists the names appearing in published descriptions considered during the course of this revision.

2. GENERIC CONSIDERATIONS OF *ACARUS* LINNAEUS, 1758

Acarus Linnaeus, 1758

Tyroglyphus Latreille, P. (1796). *Précis Caract. Ins.:* 185.
Aleurobius Canestrini, G. (1888). *Prospetto dell' Acarofauna Italiana*, **3** : 399–402, Tav 30, Fig. 1.

The name *Tyroglyphus* Latreille, 1796 has been placed on the Official Index of Rejected and Invalid Names in Zoology, as a junior objective synonym of *Acarus* L., 1758 (Hemming & Noakes, 1958a).

Type species : *Acarus siro* Linnaeus, C. (1758). *Syst. Nat.* (ed 10) **1** : 616 (as selected by Latreille, P. (1810). *Consid. gen. Anim. Crust. Arach. Ins.:* 425, 132 ; as interpreted by Fabricius, J. C. (1794). *Ent. Syst.* **4** : 430).

In 1758 Linnaeus recognised two varieties of *Acarus siro*, which he named *farinae* and *scabiei*. In his opinion they did not differ morphologically but had different habitats. His diagnosis for " *A. siro* " is given below, followed by his habitat records for the two varieties :

" A. lateribus sublobatis pedibus quatuor posticis longissimis, femoribus capiteque ferrugineis, abdomine setoso."

" Habitat in Farina Europae, Americae. Inter sirones Farinae, Scabiei, Dysenteria, Hemitritei, non reperi alias differentias, quam a loco petitas. Amoen. acad. **3**, p. 333."

In his personal copy of the tenth edition of *Systemae Naturae*, 1758 (now held by the Linnean Society, London) Linnaeus wrote above the words "in Farina Europae, Americae " the words " in caseo diutius asservatis ". This addition appears in print in the 12th edition of *Systemae Naturae*, published in 1767.

According to Declaration No. 94 of the International Commission on Zoological Nomenclature, *farinae, Acarus siro* [var.] Linn., 1758 is a junior objective synonym of *siro, Acarus* Linn. through the " First Reviser " interpretation made by Fabricius in 1794 ; this name *A. siro* Linn., as interpreted by Fabricius (1794), is the name of the type species of *Acarus* Linn., 1758 through the selection made by Latreille in 1810.

Fabricius' first account of *Acarus*, published in 1775, closely followed that of Linnaeus (1758). He, like Linnaeus, recognised a species *A. siro* with two varieties *farinae* and *scabiei*. However, in his second account of *Acarus*, published in 1781, among others he listed a species *A. siro* without varieties, followed by a species *A. scabiei*, also without varieties. His diagnosis and habitat locality for these two species is given below (I have inserted square brackets about certain words).

" 21. *siro* A. [Albidus] femoribus capiteque ferrugineis, abdomine setoso."

" Habitat in farinae. Caseo diutius asservatis."

" 22. *scabiei* A. [Albidus], pedibus [rufescentibus] posticis quatuor [seta] longissimis."

"Habitat in Ulceribus scabiei, cutem rugas secutus penetrat titillatiorem & vesiculam excitat. . ."

If we compare the above diagnosis with that previously quoted for "*A. siro*" L., 1758, the following observations can be made. Excluding those words which I have placed in parentheses, the two diagnoses of Fabricius (1781), when added together, constitute Linnaeus 1758 diagnosis for "*A. siro*", except that Linnaeus' phrase "lateribus sublobatis" is omitted. The re-arrangement of Linnaeus' phrase "pedibus quatuor posticis longissimis", together with the inclusion of the word "seta", suggests that Fabricius believed this phrase referred to the "itch" mite, and that Linnaeus had mistaken the long terminal seta which arises from tarsus III and IV to be the terminal segment of leg III and IV. Oudemans (1913) independently reached the same conclusion.

A comparison of the habitat localities associated with these three descriptions reveal that the habitat of *A. siro* Fab. is identical to that of *A. siro* [var.] *farinae* Linn., as it appears in *Systemae Naturae*, edition 12 and the habitat of *A. scabiei* Fab. compares favourably with that of *A. siro* [var.] *scabiei* Linn., 1758.

In these circumstances we must conclude that, according to the "First Reviser", Linnaeus had mistakenly compounded two species. Further evidence to support this conclusion is given by Heilsen (1946) who reported that Linnaeus was of the opinion that the varieties *farinae* and *scabiei* were identical as regards pathogenicity, and children might have scabies transmitted to them through being dusted with flour. I submit, therefore, that in his work of 1781 Fabricius, by recognising two species, was truly making a taxonomic advance. This work in spite of Declaration 94 thus truly constitutes the first revision. It follows that *farinae*, *A. siro* [var.] Linn., 1758 is objectively identical with *siro*, *Acarus* Linn., 1758, sensu Fabricius 1781.

Nomenclatorally, it is fortunate that Fabricius' 1781 and 1794 texts are virtually identical. In the 1781 text, but not in that of 1794, Fabricius gave a bibliographic reference to Schrank (1776), quoting in full the latter's description of the "Käsemilbe". Schrank's 1776 description of this mite is illustrated by a figure which clearly shows the presence of an apophysis on the ventral surface of femur I.

Since there is only one generic entity known to science having this character amongst mites which have more than the remotest possibility of infesting flour and cheese, we can be sure which species or group of species Schrank (1776), Fabricius (1781) and Fabricius (1794) were considering. By Declaration 94, which informs us that Fabricius (1794) is the "First Reviser", we therefore know with a high degree of certainty that *A. siro* [var.] *farinae* Linn., 1758 is a mite capable of infesting flour and cheese which has an apophysis on the ventral surface of femur I. Elsewhere in this paper I have shown that there are five validly described distinct species in this generic taxon. Two of these species are unlikely to be that considered by Schrank (1776) since he writes "setis corpore brevioribus"; these two species (namely those referred to as *A. tyrophagoides* (Zachvatkin) and *A. gracilis* Hughes) have a "train" of setae extending from the posterior margin of the body. Moreover, both these species as far as we know are very rare, *A. gracilis* being confined to bat-roosts, *A. tyrophagoides* to forest litter in central Russia (see page 453). In the remaining three species, the body setae are very short. In this paper, these three species are collectively referred to as the *A. siro* complex.

It is not possible to recognise from their descriptions or figures which of the three species of the *A. siro* complex Linnaeus, Schrank or Fabricius were considering, since the micro-tarsal characters essential for their separation were of course not described by them. Can it be shown, that only populations of one of the three species of the complex are commonly associated with farinaceous products and with cheese? The answer is a qualified yes. Published records of the " flour mite " indicate a wide variety of habitats, namely, farinaceous products, cheese, harvested cereals, hay, grass, soil and the nests of animals and birds (see page 457 for references). This wide range of habitats stimulated a survey of material available to me (Appendix II and chapter IV). Its analysis shows that populations representing two of the three taxa making up the *A. siro* ccmplex occur in out-door habitats ; they were not recorded from flour or other farinaceous products, but did occur on cheese. By comparison, populations representing the third taxon were recorded from flour six times and from farinaceous and other processed cereals on thirty separate occasions ; they also occurred on cheese, but were seldom found in out-door habitats. I conclude, therefore, that this last-mentioned taxon is *A. siro* [var.] *farinae* Linn., 1758. Because the three species of the *A. siro* complex do not have absolutely distinct habitats, and because no type material exists (see page 433), a neotype designation for *A. siro* [var.] *farinae* is made in this paper.

It is fortunate that the diagnosis of *Acarus* accepted today coincides essentially with that based on *A. siro* [var.] *farinae* as now interpreted. Recent generic revisions (Zachvatkin, 1941 ; Hughes, 1961) characterise *Acarus* upon structures which were first considered to have generic value by Canestrini (1888), although he referred to the taxon as *Aleurobius*. Canestrini made reference to Koch (1841) who was the first to report that the femoral apophysis was confined to the male of the species he called *Acarus farinae ;* neither referred to Schrank (1776) and Fabricius (1781 and 1794).

Generic Characters (Adults).

Setae v e less than half the length of v i. Solenidion sigma$_1$ (σ_1) on genu I more than three times length of sigma$_2$ (σ_2) on same segment. Setae d_1 and l a always short. First pair of legs of male enlarged, the femur of which bears a ventral apophysis (Text-fig. 1).

Distinguishing Characters (Adults).

Solenidia sigma$_1$ on genu I more than three times the length of sigma$_2$. Claws of female never bifid. Femur I of male enlarged, bearing ventrally a cone shaped apophysis.

Morphological Variation.

Many of the morphological characters of *Acarus* specimens show remarkably little variation from one individual to another and from species to species. Some are common to other genera within the family Acaridae whilst others serve to

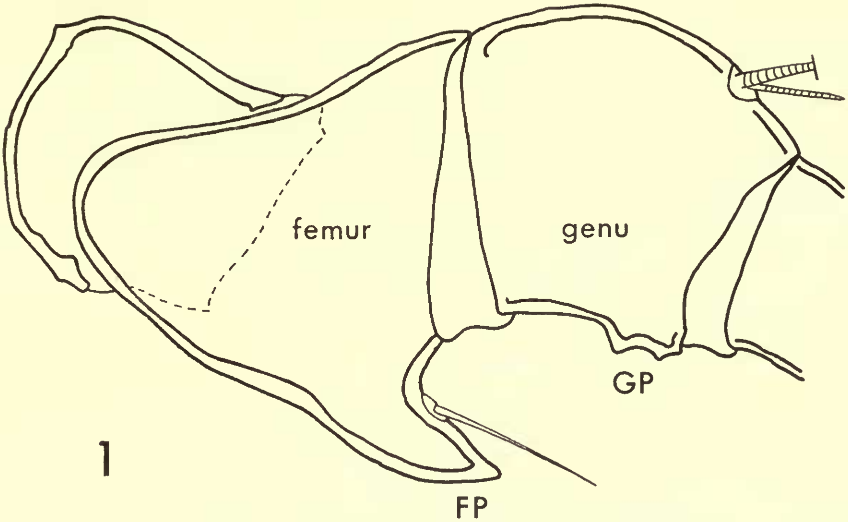


FIG. 1. *Acarus siro* L., male. Femur I and genu I, illustrating femoral apophysis (FA) and genual protrusions (GP). ×2100.

distinguish the genus *Acarus*. These characters are discussed below with reference to the adult stage.

The number of pairs of setae on the dorsal and ventral surfaces of the body is constant. I have never found an individual in which a pair or one of a pair of setae is suppressed. The position of these setae is the same for all species except that in *A. gracilis* specimens setae d_2 are much closer to setae d_1. The length of the vertical internal setae is always about 4 to 5 times that of the vertical external setae.

The structure of the male or female genitalia is extremely similar for all species. Robertson (1961) in her study on variation in the closely related genus *Tyrophagus* found specific differences in the morphology of the male genitalia. I have not found this to be the case in the genus *Acarus* ; the species cannot be separated on the shape of the penis or its supporting structures.

The male secondary sexual characters are common to all species. In only one case can they be used to differentiate a species and this provides a separation between *A. gracilis* and the *A. siro* complex. In *A. gracilis* the pair of suckers on tarsus IV are large and close together on the basal third of the tarsus whereas in specimens of the *A. siro* complex they are much smaller and separated by a greater distance.

Morphological characters which serve to differentiate the species are given in the key to species. These do, of course, vary between specimens but the amount of overlap between species is either extremely small and probably due to imperfections in mounting technique or non-existent. Only one of the diagnostic characters can, by itself, be used to distinguish between all the species in the genus. This character is solenidion omega$_1$, situated on tarsus I and II (Plate 1). Because the difference is one of shape, orientation of the specimen plays an essential part when the identity of a specimen rests solely on this character. In the closely related genus *Tyrophagus*

Ouds., 1924, the shape of solenidion $omega_1$ is different for many species (Hughes, A. M., 1961 ; Robertson, 1959).

Griffiths (1963, Ph.D. thesis unpub.) has shown that characters which Oudemans used in 1905 and 1913 to distinguish the species *Acarus farris* (Ouds. 1905) are not reliable. He also suggests that the variation exhibited by these characters is probably diet-related or due to variation in angle of viewing. The characters which Oudemans selected are:—

1. Intensity of colouring of the appendages ;
2. The number of pectinations on the supra-coxal seta ;
3. The number of protrusions of Grandjean's organ ;
4. Length and shape of tarsi ;
5. Relative length of idiosomal setae.

3. KEYS TO AND DESCRIPTIONS OF SPECIES

Key to Adults

1 Dorsal setae d_2 and d_3 not more than twice the length of d_1 . . (***A. siro*** complex) 2

– Dorsal setae d_2 or d_3 five to six times longer than d_1 4

2 Ventral, distal spine " s " of tarsi I and II (not tarsus I of ♂) large, about equal to length of tarsal claw ; ventro-posterior margin concave, tip directed backwards (Text-fig. 18). Solenidion $omega_1(\omega_1)$[1] of tarsus II recumbent, with distinct " goose-neck " before terminal expansion (Pl. I, fig. 1) . . . ***A. siro*** (p. 432)

– Spine " s " slender, about half length of tarsal claw ; ventro-posterior margin convex, tip directed forward (Text-figs. 6 & 24). Solenidion $omega_1$ at 45° angle, without distinct neck preceding terminal expansion 3

3 $Omega_1$ with sides expanding gradually from base then narrowing to an indistinct neck before expanding into terminal head. Width of widest part of head equal to width of widest part of stem (Pl. I, fig. 2) . . . . ***A. farris*** (p. 421)

– $Omega_1$ with sides almost parallel, expanding into a distinct egg-shaped terminal head which at widest part is wider than widest part of stem (Pl. I, fig. 4) ***A. immobilis*** sp. n. (p. 443)

4 Scapular setae (sc e and sc i) of almost equal length ; d_2 five to six times longer than d_1 (Text-fig. 34). $Omega_1$ of tarsus I and II gradually tapering from base to apex (Pl. I, fig. 3) . . . . ***A. gracilis*** (p. 448)

– External scapulars (sc e) more than twice length of internals (sc i) ; d_2 about equal in length to d_1, with d_3 five to six times longer (Text-fig. 40). $Omega_1$ gradually expanding from base to apex (Text-fig. 41) . . . ***A. tyrophagoides*** (p. 453)

Key to hypopi

1 In dorso-ventral mount, terminal three or more segments of legs I and II extend beyond margin of body. Gnathosoma bears pair of long terminal aristiform bristles. Sucker plate with eight distinct suckers . . (Motile hypopal form) 2

– Legs short ; in dorso-ventral mounts tarsi of legs I and II are the only segments completely visible. Gnathosoma rudimentary, aristiform bristles not present. Only one pair of well-developed suckers on sucker plate . (Inert hypopal form) 3

2 Hysterosomal setae d_1, d_2, d_3 and l_1 almost as long as scapulars (sc i and sc e). Sc i about 1·2 times length of d_1 and 1·5 times l_1. Setae d_1 and l_1 about 3 times longer than d_4 (Text-fig. 16). Bases of genital setae and flanking pair of coxal suckers almost in line, distance between base of sucker and base of seta is less than width of setal base (Text-fig. 17) . . . . ***A. siro*** (p. 434)

[1] All descriptions of solenidion $omega_1$ are based on true lateral views.

– Hysterosomal setae appreciably shorter than scapulars. Sc i about 2 times length of d_1 and 3 times l_1. Setae d_1 and l_1 about equal in length to d_4. Bases of genital setae just forward of coxal sucker bases. Distance between base of sucker and base of seta about equal to width of setal base (Text-fig. 5) . ***A. farris*** (p. 425)

3 On sucker plate the central pair of suckers vestigial, anterior peripheral pair moderately well developed (Text-fig. 27). All setae on tarsus III and IV shorter than length of tarsus, spine-like, never leaf-shaped (Text-figs. 30 and 31). Omega$_1$ long, at least twice length of tarsal claw (Text-fig. 28) . . . ***A. immobilis*** (p. 445)

– Central pair of suckers are well developed, peripheral pairs vestigial (Text-fig. 35). All setae on tarsus III and IV longer than length of tarsus, leaf-like or pectinate (Text-figs. 38 and 39). Omega$_1$ at least three times shorter than tarsal claw (Text-fig. 36) . . . . ***A. gracilis*** (p. 450)

The *Acarus siro* complex

This includes three species which have been confused one with another and generally referred to under the name *Acarus siro* L., 1758 or *Tyroglyphus farinae* Latreille or *Aleurobius farinae* of various authors. A new specific name is proposed for one of the species which has not been recognised as distinct and for which no valid name is available. *Acarus farris* (Oudemans, 1905) is re-erected and included in the complex and the third species is *Acarus siro* L., 1758 for which a neotype is designated. An appendix to this paper lists the names appearing in published descriptions which have been considered.

In this paper, differentiation of the species making up the complex is based on morphological differences in the adult and hypopal stages. Griffiths (1962) and (1964 in prep.) has established, through hybridization experiments, that the species are reproductively isolated, although some gene exchange between species is possible.

Acarus farris (Oudemans, 1905) **comb. n.**

Aleurobius farris Oudemans, A. C. (1905). *Ent. Ber. Amst.* **2** (26) : 20.

In 1913 Oudemans described *farris* more fully and transferred it to the genus *Tyroglyphus*. In 1925 he reduced *farris* to below species level saying that it could, at the most, be regarded as a weak race of *Tyroglyphus farinae* L.

Syntypes : in Oudemans' collection there are seven slides of this species labelled " Type ". They represent material taken from three separate localities at different times. Since Oudemans' original description is based on the material from one of the three localities, then only specimens making up this material are syntypes, namely ; specimens on slides numbered 45, 46 and 47 ; taken from cheese, Arnhem, February 1902. From these specimens I have previously selected as lectotype the single male mounted on slide number 45 (Griffiths, 1962). Other specimens seen are listed under " habitat and distribution records " (see page 431).

Male (Text-fig. 2). Length of idiosoma of six males, reared on wheat germ at 90 per cent relative humidity and 20°C., = 0·365 mm. average.

Idiosomal measurements were taken from the centre of an imaginary line connecting anterior tips of the epimeron fork to the centre of the posterior margin of the body.

The body is colourless, the legs and part of the gnathosoma vary in colour according to the diet. The limbs of mites collected from out-door habitats are generally pale yellow or pale rose, whereas culture reared mites feeding on yeast or wheat germ have dark red to reddish brown legs and gnathosomal extremities. Mites reared on gluten resemble wild populations in their colouring.

The body is oval, the posterior margin is evenly rounded.

(i) Body setae :

These are fine, some are smooth and others sparsely pectinate. On the dorsal surface the following pairs of setae bear pectinations which are easily visible when viewed with an oil immersion objective of phase-contrast equipment:

vertical internals (v i)
both pairs of scapulars (sc e) and (sc i)
internal sacrals (sa i)

Pectinations of the following pairs of setae are spaced further apart and are less distinct :

external verticals (v e)
external humerals (h e)
posterior laterals (l p)
fourth dorsals (d_4)
external sacrals (sa e)

The following pairs of setae appear to be smooth :

first dorsals (d_1)
second dorsals (d_2)
third dorsals (d_3)
internal humerals (h i)
anterior laterals (l a)

With the exception of the ventral humeral pair of setae (h v) all setae on the ventral surface are devoid of pectinations. This includes the long, stout pair of posterior anal setae (pa_2).

(ii) Dorsal surface :

A propodosomal dorsal shield is present. The shield is roughly bell shaped, its anterior corners are acute and the posterior corners well rounded. It extends from the bases of the v i setae (which are just within and central of its anterior border) to a point just in front of setae sc i.

The v i setae extend forward over the gnathosoma. In life, they diverge slightly outwards and curve downwards over the chelicerae. The v e's are one fifth as long as v i's and arise contiguous with the lateral margins of the propodosomal shield, close to the anterior corners. Two pairs of scapular setae (sc e and sc i) arise in a transverse row across the propodosoma, behind the shield and on a level with coxae II. Sc e are a little longer than sc i. Expressed as a percentage of the idiosomal measurement used here they are 23·5 and 23·0 per cent, respectively.

A pair of Grandjean's organs arise from the anterior-lateral margins of the propodosoma. Each is a flattened semi-circular plate, the free margins of which are drawn out into flame-like filaments. The plate is partially cleft down the centre, dividing the filaments into two groups. A few of the processes nearest to the cleft are quite long and appear to follow a similar pattern in all specimens. The filaments on the lateral edges of the plate are small and numerous. Because this organ is difficult to perceive and appears to vary in shape, possibly according to the angle of viewing, it is not used as a diagnostic character in this work. A lateral sclerite curves backwards from the base of each Grandjean's organ, encircling above coxa I. A supra-coxal seta arises from the posterior part of each sclerite. This seta is expanded at the base, tapering to a fine slender point. Strong pectinations branch out along its entire length.

The normal complement of setae for the Acaridae arise from the dorsal surface of the hysterosoma. Their position relative to one another is given in Text-fig. 2. Sa i is the longest, at about thirty-six per cent. of the idiosomal length. The remainder are quite short with average lengths as follows ; d_1 – 5%, d_2 – 7·5%, d_3 – 8·7%, d_4 – 9·5%, l a – 5%, l p – 10%, sa e 9·3% of idiosomal length.

Three pairs of circular " pores " (function unknown) are situated on the dorsal surface of the hysterosoma. One pair arise just behind the h e setae ; another on the lateral margins of the body just anterior to the openings to the " fat " or latero-abdominal glands, which themselves open on to the surface a little behind and dorsal of coxa IV. The third pair lie on the postero-lateral border of the body, just lateral to the bases of sc e (Text-fig. 2.)

(iii) Ventral surface :

A pair of ventral humeral setae (h v) lie immediately in front of coxae II ; two pairs of coxal setae just forward of coxa I and IV ; three pairs of genital setae (g) and one pair of anal setae (pr a), one on each side of the anterior half of the anal opening which is a slit-like opening on mid-line of body. All these setae are short, never longer than l p ; h v are pectinate, the remainder smooth with whip-like extremities. Posterior half of the anal opening is straddled by a pair of anal suckers. The bases of six setae (three pairs of post anals pa) form an arc which runs parallel to hind margin of the body. The most anterior pair (pa_1), one at each end of the arc, arise well behind the posterior margins of the anal suckers ; they are short, barely reaching the edge of the body. The second pair (pa_2) are three times longer and the third pair (pa_3), in line with and posterior to the anal suckers, are about twice as long as pa_1 ; all these setae are smooth. A pair of circular pores are lateral and external to pa_3.

The genital aperture, in mid-line between coxae IV, is large ; lateral arms of penis support slender, diverging posteriorly with slightly incurved tips. Basal element of penis with curved posterior margin, extremities enlarged. Penis is a short truncated tube curved downwards at apex.

Apodemes of legs I united in mid-line forming a short sternum ; those of legs II, III and IV free. Apodeme III narrow along entire length ; those of legs II and IV with distal half expanded to broad paddle-shape, each terminating in short backwaɹd directed hook.

(iv) Legs :

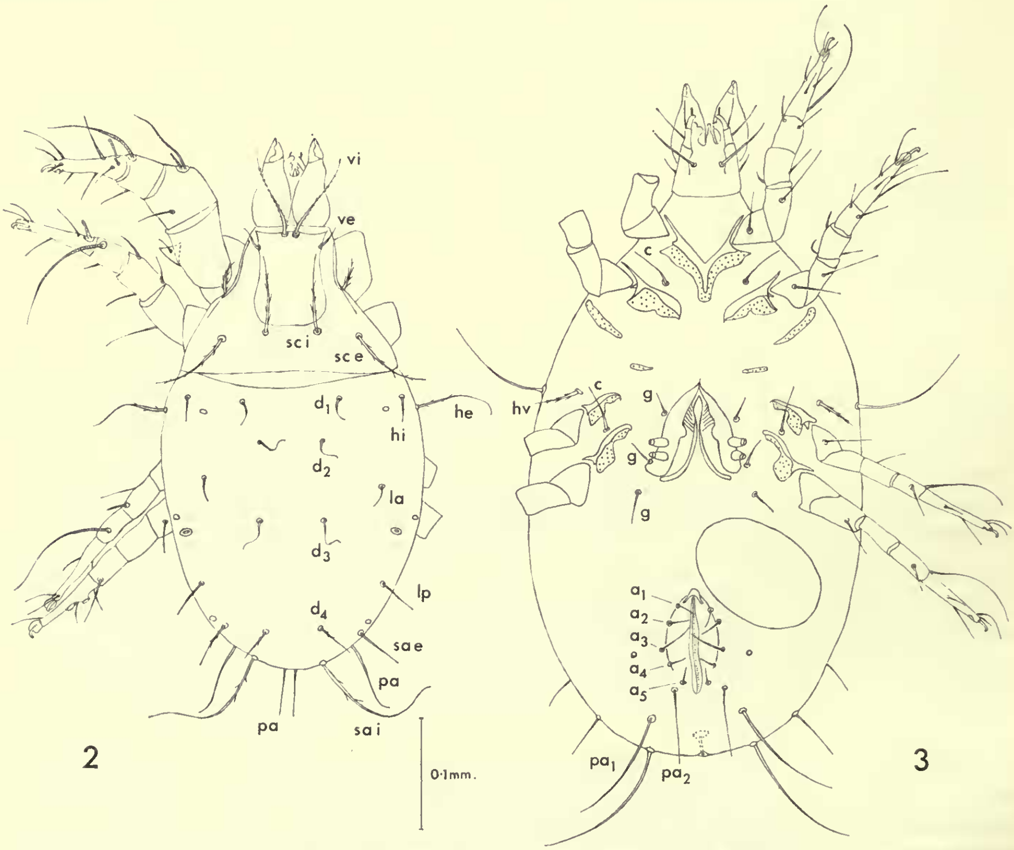
Five segmented with a well-developed pre-tarsus terminating in stalked claw.

Genu and femur leg I much enlarged ; strong spur or apophysis projecting downwards and forward from ventral surface of femur ; femoral seta (vF) arises from base of spur ; ventral surface of genu bearing two small tooth-like projections. Tarsus IV bears two copulatory suckers.

FEMALE (Text-fig. 3). Body larger and more roundly oval. On dorsum, the idiosomal setal pattern and pectinations, Grandjean's organs, supra-coxal setae, propodosomal shield and circular " pores " are as for male.

(i) Ventral surface :

Differers from male in absence of anal suckers, structure of genital aperture and number plus arrangement of anal and post-anal setae.



FIGS. 2–3. Fig. 2, *Acarus farris* (Ouds.) ♂. Dorsal view. Setae of the idiosoma : ve, vi, sc e, sc i, he, hi, d_1 to d_4, la, lp, sa e, sa i. Fig. 3, *Acarus farris* (Ouds.) ♀. Ventral view. Setae of the idiosoma : hv, c, g, a_1 to a_5, pa_1, pa_2.

Genital aperture (Text-fig. 3) is an elongate slit along mid-line of body, extends from coxa III back to coxa IV and is enclosed by two diverging genital folds which are also present in male. Anal opening (Text-fig. 3) surrounded by five pairs of anal setae (a_1 to a_5) ; a_1, a_4 and a_5 about equal in length ; a_2 about one third longer and

a_3 about twice as long. Only two pairs of post anal setae present (pa_1 and pa_2) ; pa_2 about twice length of a_3 and barely reaching posterior margin of body ; pa_1 about twice length of pa_1, extend well beyond posterior margin of body. In centre of this margin bursa copulatrix opens into base of a cuticularised saucer-shaped structure.

(ii) Legs :

Legs I not wider than others ; femur I not bearing spur and genu I without projections ; tarsus IV not bearing copulatory suckers.

LARVA. Setae, in proportion to idiosomal length, shorter than those of adult ; sc's shorter than v i ; pa twenty per cent of idiosoma. Pair of coxal rods on coxal fields I, elongate cylinders terminating in a transparent sphere. Setae d_4, two pairs genitals, anals and two pairs of post anals absent ; no genital sensory organs. Three pairs of legs.

PROTONYMPH. Dorsal setal pattern as for adult but proportionally shorter ; d_4 present. Ventral surface differs from larva and adult in that one pair of genital setae, three pairs anal, one pair post anal setae and one pair genital sensory organs are present. Coxal rods absent. Four pairs of legs present.

TRITONYMPH. Very like adult female, except that setae are a little shorter and genital aperture is present as a single slit-like opening not enclosed by folds.

HYPOPUS (Text-figs. 4, 5). This is a motile form.

Body length (anterior margin of propodosoma to posterior margin of hysterosoma): average 20 specimens = 0.240 mm.

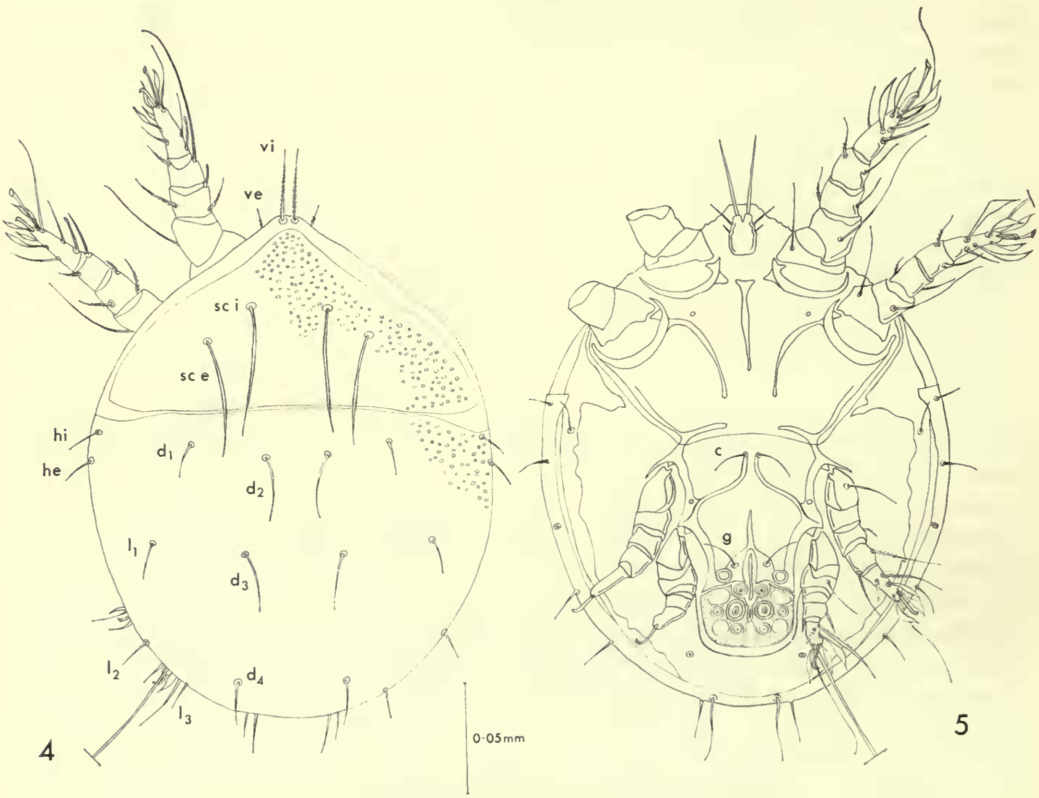
Colour of live specimens pinkish-beige. Dorsal surface, convex with fine irregularly spaced punctations, is divided into a distinct propodosoma and hysterosoma. Eyes not present.

Strongly pectinate v i setae project forward from tip of propodosoma. They are about ten per cent of body length ; v e are one fifth as long. Bases of two pairs scapular setae traverse propodosoma on level with coxae II ; both pairs are fairly long about twenty five per cent of body length, sc i being slightly longer than sc e.

Setae of hysterosoma appreciably shorter than sc i and sc e. Four pairs arise in a transverse row immediately behind groove which separates propodosoma from hysterosoma ; h e and h i near latero-anterior margin of hysterosoma and d_1, d_2 with bases in line with bases of scapulars. Thus, pair d_2 is displaced forward compared with its position in the adult and other stages. Pairs d_3 and d_4 are in linear series with d_2. Seta d_1 is slightly longer than d_4 ; d_2 and d_3 are about 1·5 times d_1. Three pairs of short laterals present ; l_1 is lateral to d_3, almost same length as d_1 and a little shorter than d_4; l_2 and l_3 lie on body margin between l_1 and d_4. Two pairs of setae, possibly homologous with the sacrals, project from posterior margin of body. A pair of glands open on lateral margin of body on a level with coxae IV.

On the ventral surface the gnathosoma is a much reduced unpaired plate, terminating in a pair of lobes from each of which an aristiform bristle arises. Two pairs of shorter bristles occur on lateral margins of plate. No mouth.

Sternum not forked, free as are apodemes I. Epimerites II well marked, extending backwards and converging slightly to join apodemes III, then running forwards and inwards towards mid-line of body. Apodemes IV curve gently forwards towards mid-line but just before meeting they angle sharply forward, running parallel on either side of mid-line for a short distance before ending ; not meeting apodemes III. A pair of coxal setae arise on surface of body at point where apodemes IV peter out. Rims of coxal cavities II, III and IV distinctly thickened. Internal rims of coxae IV " L " shaped, horizontal arms running parallel to anterior margin of sucker plate, then forward on either side of genital opening, fusing anteriorly to genital opening and then proceeding forward for short distance along mid-line.



FIGS. 4–5. *Acarus farris* (Ouds.), hypopus. Fig. 4, dorsum. Fig. 5, venter.

A pair of genital setae arise on either side of genital slit ; laterally, and at forty-five degrees backward from each seta, is a sucker ; the distance between bases of sucker and seta is about the width of the setal base.

Sucker plate (Text-fig. 5) small, consisting of central pair large suckers surrounded by three pairs of peripherals ; anterior pair shaped like a truncated cone, projecting further from body than the others. Four clear areas, which Hughes (1961) considers to be vestigial suckers, separate the three pairs of peripheral suckers.

Leg chaetotaxy of all stages. The nomenclature used is that devised by Grandjean (1939).

(i) Female (Text-figs. 6, 7 and 8), male (Text-fig. 9) and tritonymph.

Leg I of these three stages bears the most solenidia and setae ; legs II, III and IV show progressive simplification (see formulae below). Chaetotaxy of tritonymph legs identical to that for corresponding legs of female, as are legs II and III of male ; certain modifications occur on tarsi I and IV of male.

Distal end of tarsus I encircled by eight setae ; d, e, f, fine slender smooth, p, q, u, v and s are short spines. Seta d, situated dorsally, is the longest ; f on post-axial face is half the length of d ; e on pre-axial face short, half length of f. Ventrally,the pair of spines v and u lie on either side of mid-line anterior and internal to pair p and q ; all four spines are small, slender and difficult to see. Spine s lies on mid-line posterior to others ; when viewed laterally, spine s is about half to two thirds length of tarsal claw.

Solenidion omega$_3$ (ω_3) is anterior to d just post-axial to mid-line. Mid region of tarsus bears whorl of four setae, ba, la, ra and wa. Basal third bears two solenidia, omega$_1$ (ω_1) and omega$_2$ (ω_2), the famulus, epsilon (ε), and one seta aa. Omega$_1$, when viewed laterally, has margins which diverge slightly from base upwards then narrow almost imperceptibly before expanding slightly into a terminal head ; the angle between its anterior margin and dorsal surface of tarsus is rarely less than forty-five degrees.[1] See Pl. I, fig. 2.

Famulus, (ε) shaped like a minute spine, arises from a small pit anterior to omega$_1$. Omega$_2$ rod-shaped half length of omega$_1$, situated on post-axial face.

Setae of tibia I (gT and hT) strongly pectinate ; solenidion psi (φ) long, whip-like, arising from distal dorsal point of tibia and extending beyond extremity of tarsus.

Genu I setae (cG and mG) also strongly pectinate. Two solenidia, sigma$_1$ (σ_1) and sigma$_2$ (σ_2), project from a depression on dorsal distal margin of genu ; sigma$_1$ about three times longer than sigma$_2$. Femur I and trochanter I each bear a single seta, vF and pR, respectively. Chaetotaxy of leg I of male same except spines v and u are fused forming a single scale-like spine larger than s, which is a thin spine.

Leg II as for leg I except aa, omega$_2$, omega$_3$ and one sigma are absent (Text-fig 7). Leg II of male same.

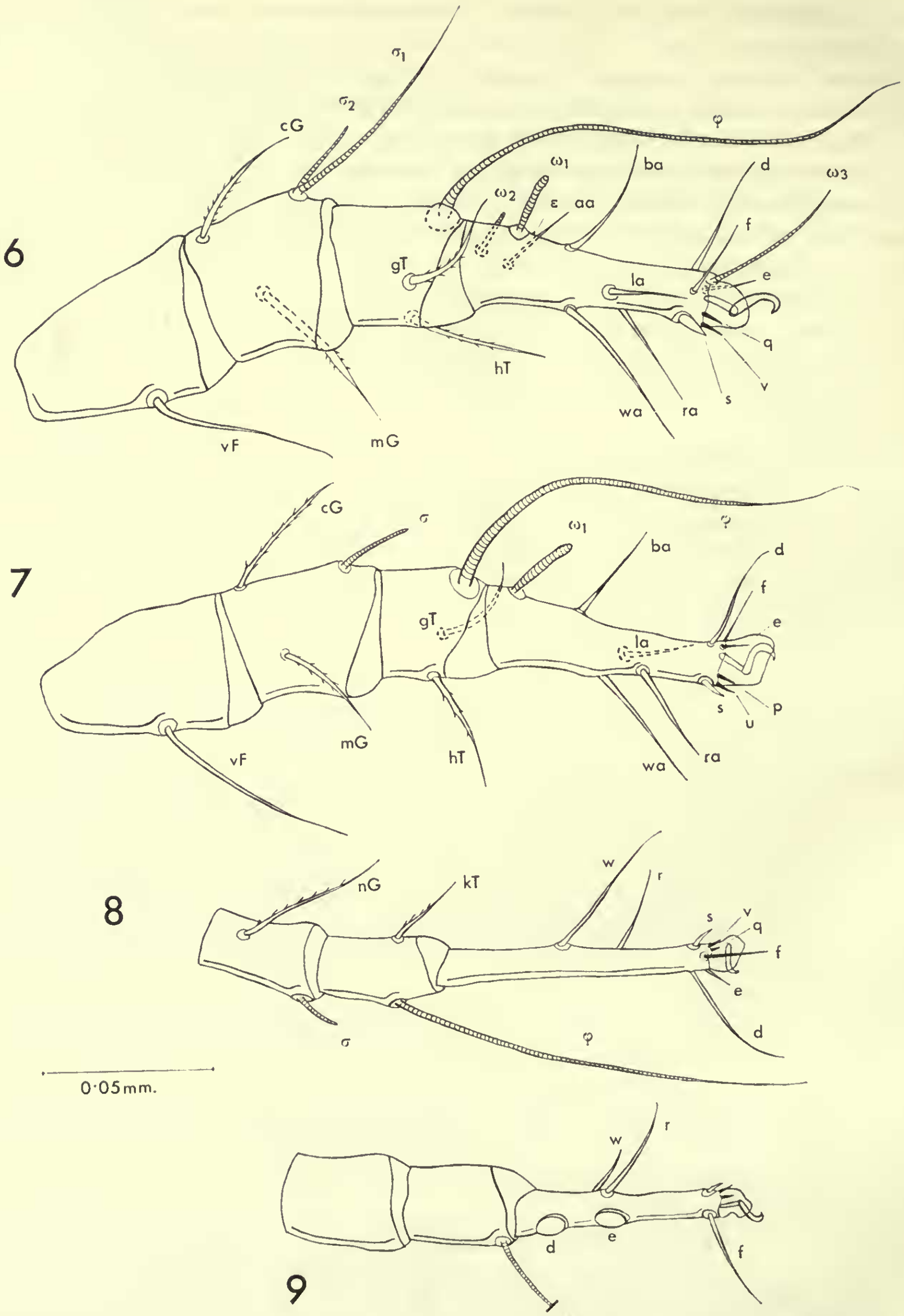
On leg III, setae ba, aa, l, gT, cG, wF are missing ; kT, nG and sR present and homologous with hT, mG and pR, respectively. Only two solenidia present, psi and one sigma (Text-fig. 8). Leg III of male same.

Psi is the only solenidion on leg IV. Setal pattern differs from leg III in that nG and sR are absent but wF (homologous with vF) is present. In the male, setae d and e of leg IV are modified into copulatory suckers (Text-fig. 9).

(ii) Protonymph and larva.

Chaetotaxy of protonymph and larva show progressive simplification, especially of solenidia. The number of setae and solenidia per segment of each leg is given below in formula fashion. Omega$_1$ of tarsus I and II in these stages has a much more defined expansion at distal end than that of adult.

[1] In the male and female, omega$_1$ of tarsus II is slightly longer than that of tarsus I. In the tritonymph, on both tarsus I and II it is more distinctly expanded at the distal end.



FIGS. 6–9. *Acarus farris* (Ouds.), adult leg chaetotaxy. Fig. 6, leg I ♀—tarsus, tibia, genu, femur. Fig. 7, leg II ♀—tarsus, tibia, genu, femur. Fig. 8, leg III ♀—tarsus, tibia, genu. Fig. 9, leg IV ♂—tarsus, tibia, genu.

(iii) Hypopus (Text-figs. 10, 11, 12 & 13).

Adapted as it is to a special mode of life, the chaetotaxy of the hypopus is different from that of the other stages. Most of the differences involve a change in shape, but a few are concerned with the expression or suppression of certain setae and solenidia. The differences are dealt with under various sub-headings, below :

(a) Structures suppressed in hypopus but present in protonymph, tritonymph and adult stages.
Omega$_2$ and one sigma on leg I, and a sigma on leg III.

(b) Present in hypopus absent in all other stages.
Seta l on legs III and IV.

(c) Arises for first time in hypopus stage.
Seta pR on legs I and II ; seta sR on leg III ; on leg IV setae e, f, kT, wF and a very short solenidion psi.

(d) Fusion of ventral spine complex in hypopus stage.
Ventral spine complex of other stages replaced by two expanded leaf-like setae.

(e) Difference in shape or in length of solenidia and setae.
The length of omega$_1$ on tarsus I and II is just over half the length of the tarsus ; it is also much more slender than that of other stages.
Setae e, f, ra, r, la, l, wa and w are different in shape. On tarsus I and II seta e is expanded at the distal end into a sucker-like structure, on tarsus III it is leaf-like and on tarsus IV it is an extremely long, thick, simple seta, about half the length of the idiosoma. Seta f is thin, transparent and leaf-like on all legs ; ra or r is leaf-like on all legs except IV where it is simple ; la or l is long and leaf-shaped on all four legs ; wa is broad, flattened and heavily pectinate ; w is broad, flattened and smooth. Solenidion psi of tibia III is of medium length and does not taper to a whip-lash.

(iv) Chaetotactic formulae.

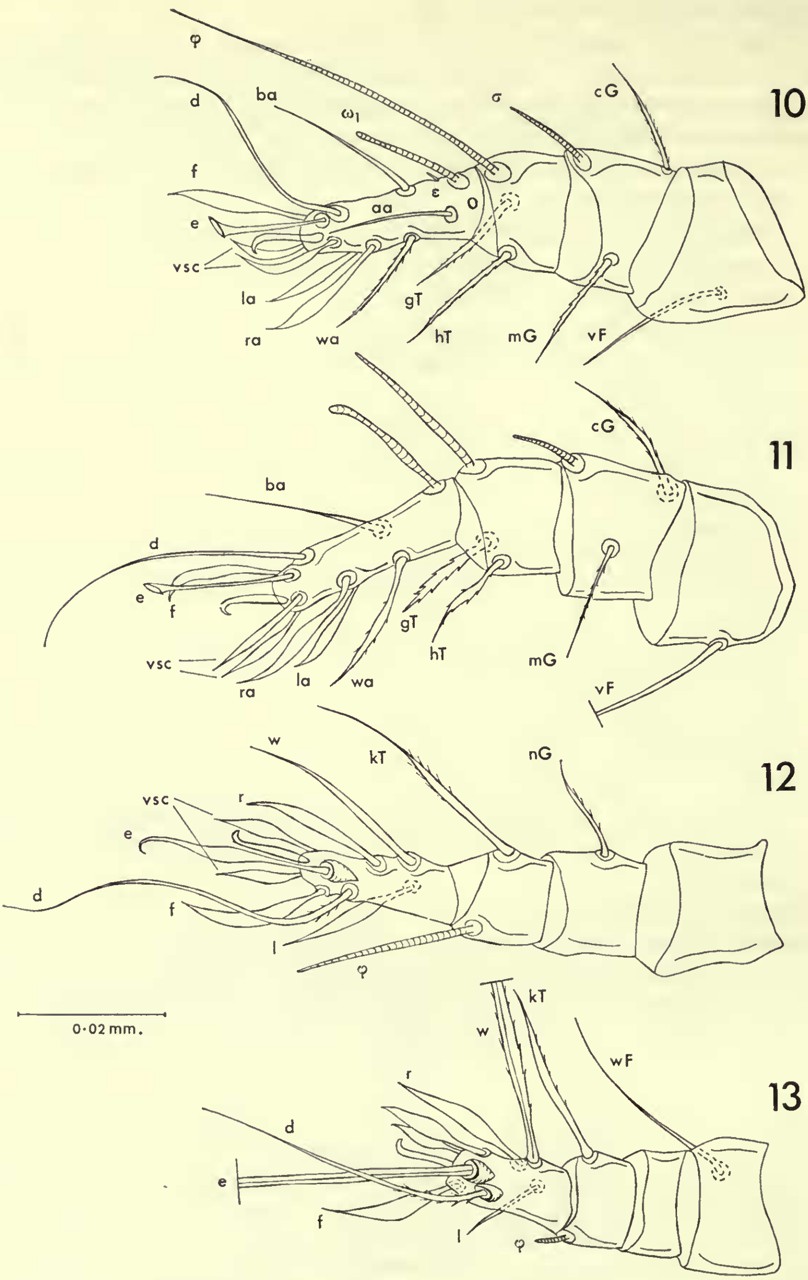
The numbers of setae and solenidia on each segment of each leg of all stages is given below in formula fashion. The famulus, which is present on tarsus I of all five stages, is not included. The five groups of figures inside each pair of brackets represent, from left to right ; tarsus, tibia, genu, femur and trochanter.

(*a*) Setae

	Leg I	II	III	IV
Larva	(13.2.2.1.0)	(12.2.2.1.0)	(10.1.1.0.0)	(—)
Protonymph	(13.2.2.1.0)	(12.2.2.1.0)	(10.1.1.0.0)	(7.0.0.0.0)
Hypopus	(10.2.2.1.1)	(9.2.2.1.1)	(8.1.1.0.1)	(8.1.0.1.0)
Tritonymph	(13.2.2.1.1)	(12.2.2.1.1)	(10.1.1.0.1)	(10.1.0.1.0)
Adult	(13.2.2.1.1)	(12.2.2.1.1)	(10.1.1.0.1)	(10.1.0.1.0)

(*b*) Solenidia

	Leg I	II	III	IV
Larva	(1.1.2.0.0)	(1.1.1.0.0)	(0.1.1.0.0)	(—)
Protonymph	(2.1.2.0.0)	(1.1.1.0.0)	(0.1.1.0.0)	(0.0.0.0.0)
Hypopus	(1.1.1.0.0)	(1.1.1.0.0)	(0.1.0.0.0)	(0.1.0.0.0)
Tritonymph	(3.1.2.0.0)	(1.1.1.0.0)	(0.1.1.0.0)	(0.1.0.0.0)
Adult	(3.1.2.0.0)	(1.1.1.0.0)	(0.1.1.0.0)	(0.1.0.0.0)



FIGS. 10–13. *Acarus farris* (Ouds.), hypopal leg chaetotaxy (excluding trochanter segment). Fig. 10, left leg I. Fig. 11, left leg II. Fig. 12, left leg III. Fig. 13, left leg IV.

Distribution. England, Scotland, Wales, Netherlands, Germany, Kenya, U.S.A. (possibly France, Morocco, Bermuda).

Habitat and Locality.

(i) A. C. Oudemans' collection, Leiden :

Utrecht (habitat not given), Sept. 1885 ; on cheese, Arnhem, 6.ii.1902 ; on cheese, Bremen, 16.ix.1904 ; on cheese, Leiden (date not given) ; *Mus rattus* (hypopus only), Arnhem, 8.x.1904 ; *Mus decumanus*, Arnhem, March 1909 ; *Cavia cobdya*, Arnhem, Feb., 1909 ; in insect collection (hypopus only), Amsterdam, 1916 ; in hole in an apple, Arnhem, 17.iii.1918 ; Berlin (habitat not given) (hypopus only), 14.v.1923 ; on the flower beetle *Osmoderma eremita* (hypopus only), Weenen, Aug., 1924 ; on a hyacinth bulb, Sassenheim, Feb., 1924.

(ii) D. A. Griffiths' collection :

At base of old barley stack in field (including hypopus), Abingdon, Wilts, July, 1959 ; in garden humus (including hypopus), Slough, Bucks., Aug., 1959 ; in hay in stables (hypopus only), Gloucestershire, Sept., 1960 ; in deep litter of chicken house (including hypopus), Hull, E. Yorks., Oct., 1960 ; in H.G. oats in farm granary (including hypopus), Haverfordwest, Pembs., Nov., 1960 ; in H.G. barley, Soulbury, Bucks., Dec., 1960 ; in sparrow's nest (including hypopus), nesting box no. 3, Kinloch farm, Island of Rhum, Scotland, Nov., 1960 ; in H.G. oats from Isle of Man, on M.V. Rema, Plymouth, June, 1961.

In farm granary (including hypopus), Kinangop, Kenya, March, 1962.

(iii) Pest Infestation Lab. (Slough) collection :

In H.G. barley (including hypopus), Scotland, May, 1945 ; on Cynipid in H.G. wheat (hypopus only), Newport, Mon., June, 1945 ; H.G. wheat (incl. hypopus), Sutton Bonington, Leics., Sept., 1945 ; grain store (incl. hypopus), Slough, Bucks., June, 1947 ; on Stilton cheese, England, Sept., 1953 ; on Australian cheese (incl. hypopus), England, Sept., 1953 ; on Cheshire cheese (incl. hypopus), Liverpool, Lancs., Sept., 1953 ; from bird's nest (unident.), Slough, Bucks., 1954 ; farm granary, Bucks., 1954 ; hay in farm store (incl. hypopus), Northants., Aug., 1955 ; from pigeon's nest, Chelmsford, Essex, Nov., 1956.

(iv) United States National Museum Collection Washington (in part) :

On onions from Morocco, imported into Boston, U.S.A., March, 1935 ; on rose flowers from Bermuda, imported into Boston, U.S.A., Aug., 1936 ; in potato cellar, Idaho, U.S.A., May, 1951 ; on tulip bulbs from England, imported into New York, 1949 ; on dahlia tubers from France imported into San Juan (?) U.S.A., 1956.

Misidentifications attributable to *A. farris* (Ouds.)

Adult form :

Berlese, A. (1884). As *Tyroglyphus farinae* (Degeer) Gervais.
Knülle, W. (1963). As Mehlmilbe formen A.

Hypopal form :

Michael, A. D. (1903). As *Tyroglyphus longior* Gervais.
Oudemans, A. C. (1905). As *Aleurobius farinae* L.
Oudemans, A. C. (1905). As *Tyroglyphus dimidiatus* (Herm).
Jary, S. G. (1936). As *Aleurobius farinae* Koch.

Oboussier, H. (1939). As *Tyroglyphus dimidiatus* (Herm.)
Zachvatkin, A. A. (1941). As *Tyroglyphus farinae* (L.)
Hughes, A. M. (1948). As *Tyroglyphus farinae* (L.)
Türk, E., & Türk, F. (1957). As *Tyroglyphus farinae* (L.)
Knülle, W. (1959). As *Acarus siro* L.
Hughes, T. E. (1959). As *Acarus siro* L.
Hughes, A. M. (1961). As *Acarus siro* L.

Material deposited in National Museums

(i) British Museum (Natural History):

Three males, four females and three hypopi, on nine slides labelled : Base of barley stack in field, Abingdon, Wilts., U.K., July, 1959, Collr. D. A. Griffiths, registration number ; 1963.8.19.1-9. One female : In garden humus (compost-heap), Slough, Bucks., U.K., Aug., 1959, Collr. D. A. Griffiths, 1963.8.19.10. About forty hypopi on one slide : Hay in stable, Gloucestershire, U.K., September, 1960, Collr. B. E. Jones, 1963.8.19.11. One male, and twelve specimens, on two slides : Deep litter in chicken house, Hull, E. Yorks., U.K., Oct., 1960, Collr. D. Walton, 1963.8.19.12-13. Two hypopi, on same slide : Home-grown oats, in farm store, Haverfordwest, Pembs., U.K., Nov., 1960, Collr. D. J. Parry, 1963.8.19.14. One male and a female, on same slide : House-sparrow's nest, in out-building, Slough, Bucks., U.K., 20.v.1963, Collr. P. Tyler, 1963.8.19.15. One male, two females and two hypopi, all on one slide, together with some *T. longior* specimens : Spillage in farm granary, Kinangop, Kenya, Elev. 8,100 ft., March, 1962, Collr. C. W. Coombs, 1963.8.19.16.

(ii) United States National Museum, Washington:

Three males, two females and three hypopi, on eight slides : Base of barley stack, in field, Abingdon, Wilts., U.K., July, 1959, Collr. D. A. Griffiths. Twenty hypopi, on one slide : Hay in stable, Gloucestershire, U.K., September, 1960, Collr. B. E. Jones. Four hypopi, on one slide : Deep litter, in chicken house, Hull, E. Yorks., U.K., Oct., 1960, Collr. D. Walton.

Acarus siro Linnaeus, 1758

Acarus siro [var.] *farinae* Linnaeus, C. (1758). *Syst. Nat.* (ed. 10) **1** : 616.
Tyroglyphus farinae Latreille, P. (1796). *Précis Caract. Ins.*: 185.
Aleurobius farinae (L.) var. *africana* Oudemans, A. C. (1906). *Ent. Ber. Amst.* **2** : 43, **syn. n.**

The specific name *farinae*, *Tyroglyphus* Lat., 1796, has been placed on the Official Index of Rejected and Invalid Names in Zoology as being a junior objective synonym of *siro*, *Acarus* L., 1758 through the " First Reviser " selection by Fabricius, J. C. (1794) (Hemming & Noakes, 1958b).

Only one specimen of the variety *africana* was available to Oudemans. This, a female labelled " *Tyroglyphus africana* Ouds., 1906, Type " in Oudemans' own handwriting, is in his collection at Leiden. I have seen the specimen and recognise it to be conspecific with *A. siro* L., 1758.

Type material.

In 1963 I made a search for the type material of *A. siro* [var.] *farinae* L.

I examined Linnaeus' own collection which is housed in the rooms of the Linnaean Society, London. This contains about one dozen large ticks, all without labels and each secured by a pin passing through the body. I am satisfied that not one of these specimens can be considered to be the type material of *A. siro* [var.] *farinae.*

Certain collections which were described by Linnaeus are kept in the museum of Uppsala Academy, Sweden. Dr. Å. Holm, curator of this museum, has informed me that there are no type specimens of Acari in these collections. It is presumed, therefore, that the type material of *A. siro* [var.] *farinae* L., if it ever existed, does so no longer.

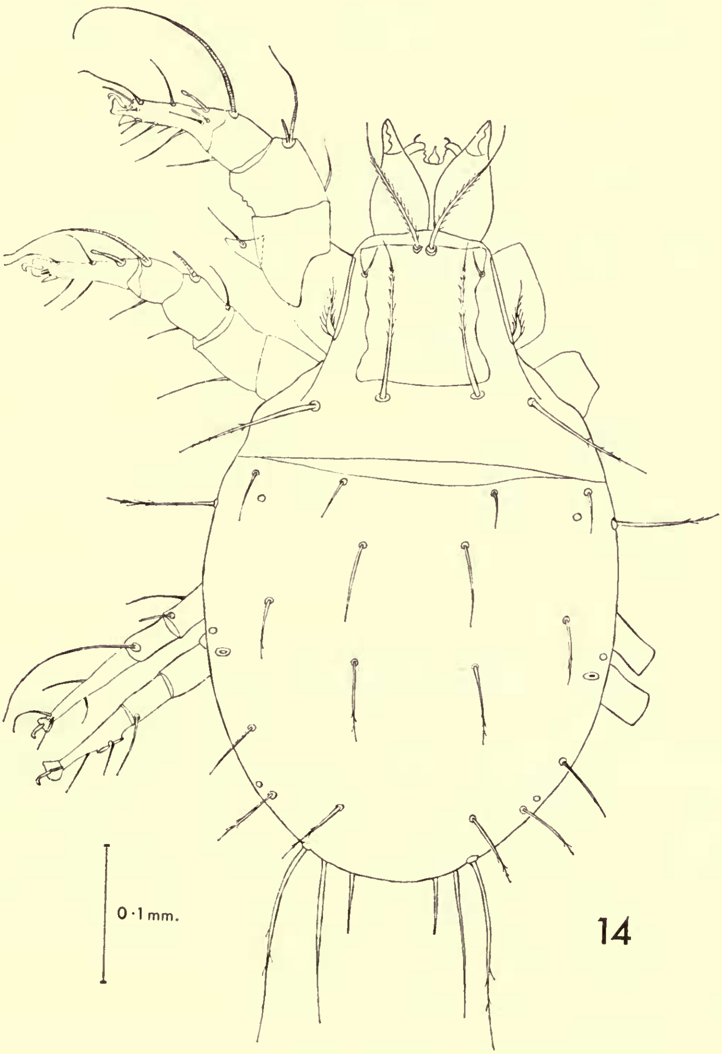


FIG. 14. *Acarus siro* L. ♂, dorsum.

Neotype designation.

In accordance with the case put forward on page 416, I designate the specimen with the following data as the neotype of *Acarus siro* [var.] *farinae* L., 1758 :
Male ; labelled : Flour residues, Calcot Mill, Berks., U.K., Collr. D. A. Griffiths, 30.v.1963. Right leg II of this male is mounted laterally under a separate coverslip but on the same slide ; mounted in Berlese fluid. Deposited in the British Museum (Natural History) registration number ; 1963.8.19.17.

MALE (Text-fig. 14). Length of idiosoma of six males reared on wheat germ at 90 per cent relative humidity and 20°C = 0.44 mm average. A larger species than *A. farris* with legs and chelicerae possibly more heavily tanned, but again degree of tanning is dependent upon kind of nutrients eaten during growing period and cannot, therefore, be used as a diagnostic character.

This species closely resembles *A. farris* and, in the main, only the differences are given below.

Degree of pectination of idiosomal setae on dorsum similar to *A. farris*, except d_3 and l a also slightly pectinate. Pectinations on scapulars appear to be confined to distal halves of the setae and to be paired. Dorsals d_1 to d_3 stronger and less whip-like. Setal pattern exactly the same as *A. farris* but generally all setae, when expressed as percentage of length of idiosoma, are slightly longer ; sa i is about forty-five per cent of idiosomal length, almost ten per cent longer than sa i of *A. farris*. Also sc e is slightly shorter than sc i, whereas the reverse is true in *A. farris*.

Propodosomal shield present, lateral margin irregular and posterior corners less rounded than in *A. farris*. Grandjeans' organs and supra-coxal setae present.

Setal pattern of venter same as *A. farris* with setae being proportionately slightly longer. Anal and post-anal setae with strong, thick bases as in *A. farris ;* pa_1 and pa_3 with few pectinations, pa_2 smooth.

No discernible differences in morphology of genitalia, apodemes and leg segmentation.

FEMALE (Text-fig. 15). Body larger than male ; setae more sparsely pectinate than male. Propodosomal shield and dorsal idiosomal setal pattern as for male. Anal setae differ from those of *A. farris* ♀ in that a_2 are twice length of a_1, a_4 and a_5 ; also a_3 are almost four times length of a_1, a_4 and a_5 ; pa_2 extend well beyond posterior margin of body with pa_1 about one and a half times longer (Text-fig. 15).

LARVA PROTONYMPH and TRITONYMPH. Dorsal and ventral surfaces of body very similar to *A. farris*. I have not found a character on the idiosoma of these three pre-adult stages which differs sufficiently between *A. siro* and *A. farris* to be diagnostic.

HYPOPUS (Text-figs. 16, 17). This has a motile form.

Body length average of 10 specimens = 0.23 mm.

Colour of live specimens pinkish-beige.

The dorsum is convex with fine irregularly spaced punctations ; divided into propodosoma and hysterosoma ; eyes not present (Text-fig. 16).

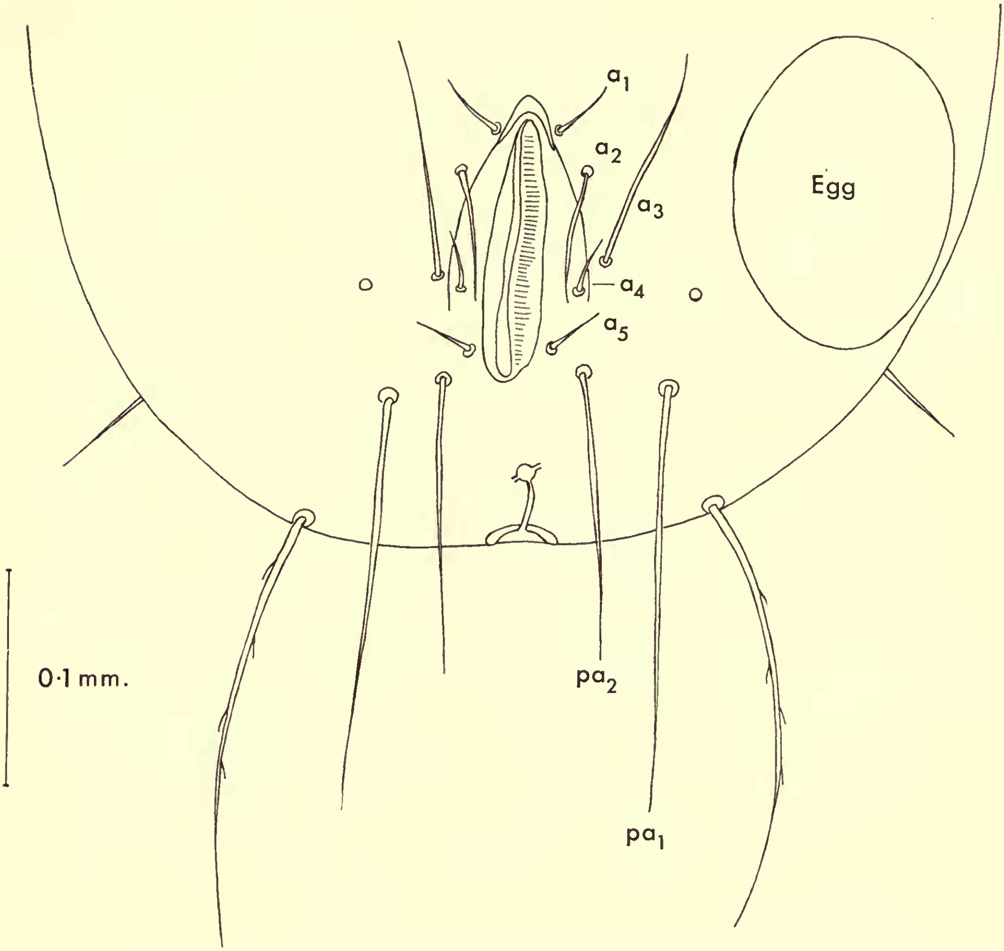


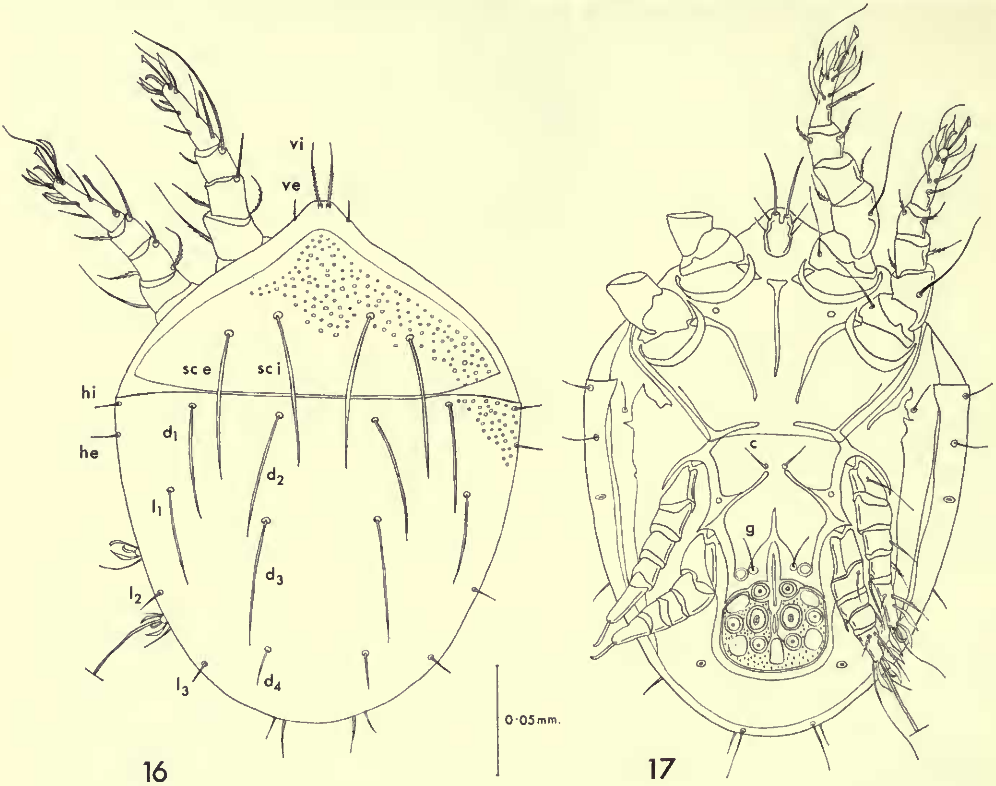
FIG. 15. *Acarus siro* L. ♀, anal region.

Dorsal setal pattern the same as that of *A. farris* but setal shape and lengths are different. Sc e and sc i of propodosoma and d_1, d_2, d_3, and l_1 of hysterosoma are long, flattened and slightly expanded in their middle region. In *A. farris,* these hysterosomal setae are appreciably shorter and barely expanded or flattened. Sc i and sc e are thirty and twenty-eight per cent of idiosomal length respectively. Setae d_2 and d_3 are almost as long as sc i, and just a little longer than d_1 and l_1. Setae d_1 and l_1 are three times longer than d_4 ; in *A. farris* these three setae are about equal in length.

The ventral surface (Text-fig. 17) is very similar to that of *A. farris* except for the following differences which have held true for the many hundreds of specimens I have examined ;

(i) Genital setae arise almost in line with pair of suckers forward of sucker-plate ; bases of seta and sucker on each side of genital opening less than width of setal base apart.

(ii) Apodemes IV barely curved and not sharply angled forward along mid-line.



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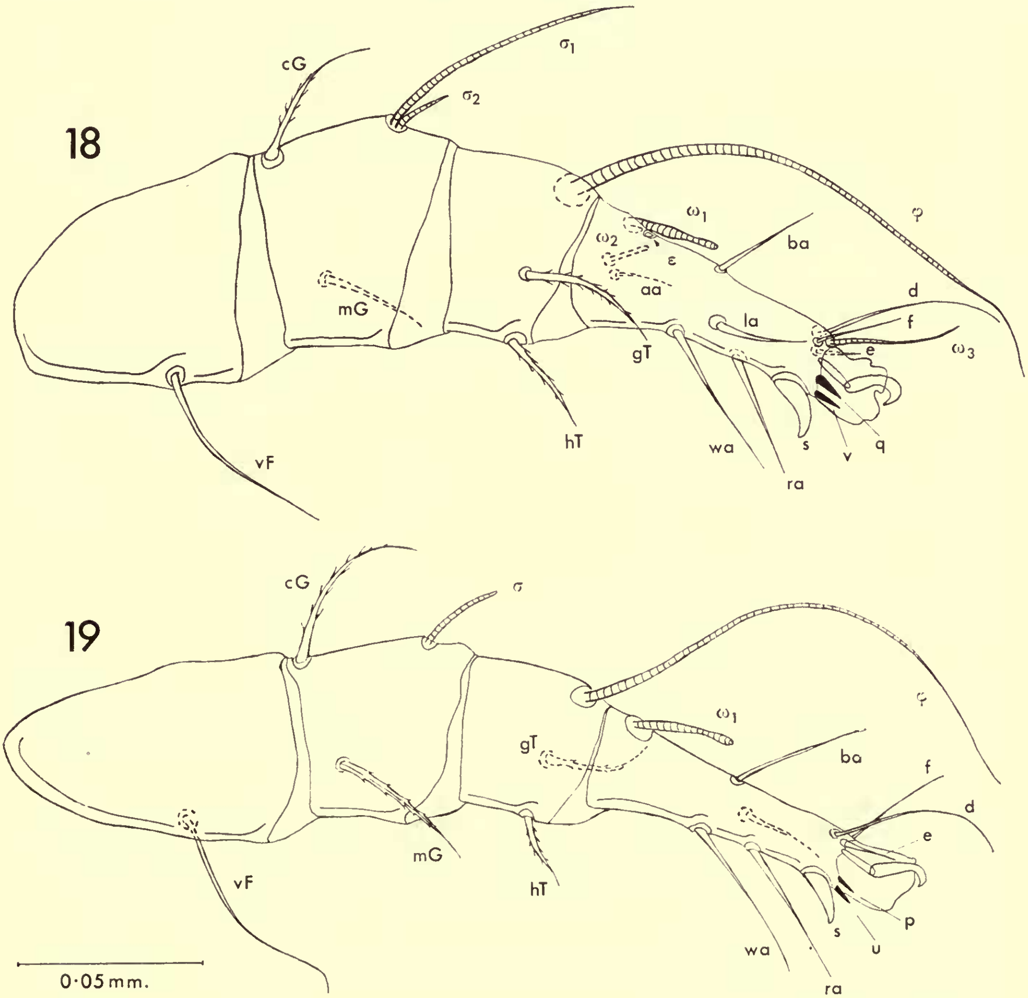
FIGS. 16–17. *Acarus siro* L. hypopus. Fig. 16, dorsum. Fig. 17, venter.

LEG CHAETOTAXY (Text-figs. 18, 19, 21 & 22). The formulae for all the legs of all stages of both setae and solenidia are exactly the same as those given for *A. farris*. Apart from individual variation common to both species, the setal pattern of all stages is also the same except for the position of one seta of the adult, namely ; ba on leg I and II of the adult is situated between and almost equidistant from the base of $omega_1$ and seta d, being slightly nearer $omega_1$ (Text-figs. 18 and 19). In *A. farris*, ba is closer to $omega_1$ (Text-figs. 6 and 7). See also Text-fig. 20, a scatter diagram obtained by plotting ratios of measurements taken from the base of $omega_1$ to ba and from ba to d for populations of *A. siro* and *A. farris*. These ratios appear to hold good regardless of tarsal length, which is very variable.

Pectinations on setae and shape of both setae and solenidia are similar in *A. siro* and *A. farris*, except there is a difference in the shape of $omega_1$ on tarsus I and II of the adult stage. This difference in shape is more pronounced on tarsus II but is not apparent unless a true lateral view of $omega_1$ is obtained.

Omega$_1$ of *A. siro* (Pl. I, fig. 1) is recumbent ; angle between dorsal surface of tarsus and anterior surface of solenidion rarely exceeds forty-five degrees. It is broadest at the base, narrowing to a distinct " goose-neck " before swelling out into a terminal expansion ; width of this expansion at widest part always less than width of widest part of stem. Shape of omega$_1$ of *A. farris* is different in that the stem narrows only imperceptibly before expanding into terminal head and width of head at widest part is about equal to width of widest part of stem (Pl. I, fig. 2).

There is a difference in the shape of omega$_1$ of the hypopus stage. In *A. siro* it is slightly " goose-necked " with a distinct terminal expansion. That of *A. farris* has a terminal expansion barely thicker than widest part of stem.



FIGS. 18–19. *Acarus siro* L., ♀ leg chaetotaxy. Fig. 18, leg I—preaxial face. Fig. 19, leg II—postaxial face.

In all other pre-adult stages, except possibly the tritonymph, the shape of omega$_1$ in both species is so similar that it cannot be used to separate the two species.

Considered in proportion to body size, the size of the leg setae (width or length) is not significantly different from those of *A. farris* except in the case of the spine-like seta s. The size of spine s on all legs of all stages (excluding the hypopus and leg I of the male) is greater on *A. siro* specimens than it is on comparable legs of comparable stages of *A. farris* specimens. When the tarsus of *A. siro* is viewed laterally the length of the longest edge (the concave margin) of spine s is equal to the length of the tarsal claw ; the width of the base is almost equal to the length of the shortest edge (the convex margin). In *A. farris* spine s is only about half the length of the tarsal claw and the width of the base is less than half the length of the shortest edge of the spine. Compare Text-figs. 6, 7 with 18 and 19.

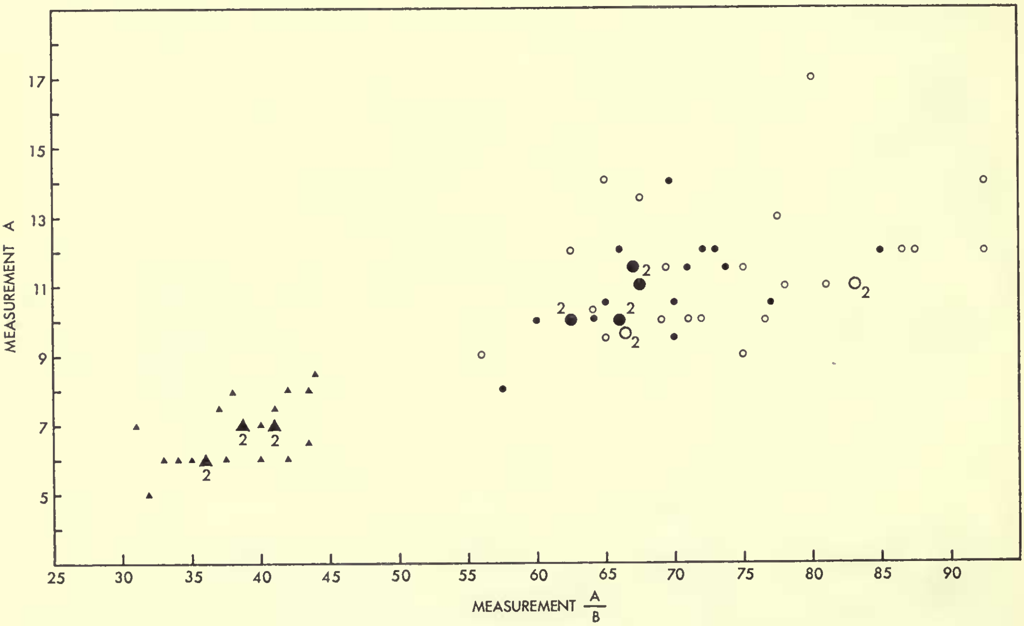


FIG. 20. Scatter diagram showing complete separation of *A. farris* from *A. siro* when measurement A is plotted against A/B. A = distance from base of ω_1 to seta ba ; B = distance from ba to seta d, tarsus II. Closed triangles = *A. farris* individuals. Open and closed circles = *A. siro* from two populations.

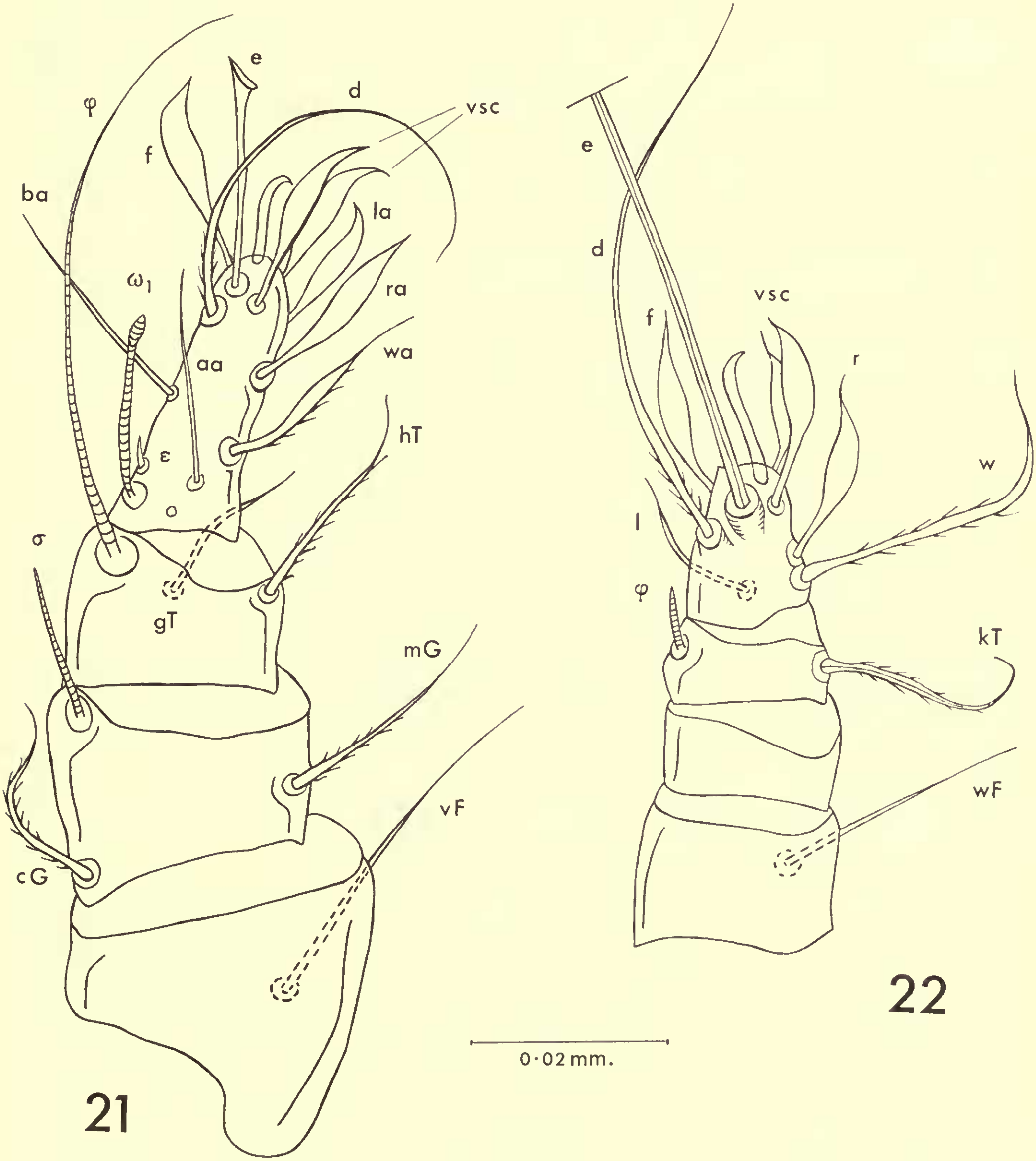
The shape and position of the setae and solenidia (except shape of omega$_1$) on the legs of the *A. siro* hypopus is exactly the same as in *A. farris*. Compare Text-figs. 21, 22 (leg I and IV of *A. siro*) with Text-figs. 10 and 13 (the same legs of the *A. farris* hypopus).

DISTRIBUTION. England, Scotland, Wales, Northern Ireland, Netherlands, Germany, Kenya, U.S.A., Chile.

HABITAT AND LOCALITY.

(i) A. C. Oudemans' collection, Leiden :

Arnhem, habitat not given, May, 1898 ; Arnhem, habitat not given, 2.ii.1902 ; corn merchant's wares, Amsterdam, Oct., 1923 ; *Evotomys glareolus*, bank vole (includes one hypopus), Hemmelsdorper See, Holland, 10.iv.1926 ; on pigs intestines, Berlin, 1927 ; on tobacco, Hamburg, Febr., 1928.



FIGS. 21–22. *Acarus siro* L., hypopus leg chaetotaxy. Fig. 18, leg I—postaxial face. Fig. 19, leg IV—postaxial face.

(ii) D. A. Griffiths' collection :

A laboratory culture, Pest Infestation Laboratory (P.I.L.), Slough, Bucks., Aug., 1959 ; a laboratory culture, Royal Free Hospital School of Medicine, London, Aug., 1959 ; cultured at P.I.L. (since 1947) Aug., 1959 ; in culture at P.I.L. since 1950, originally from warehouse, Cheshire, Aug., 1959 ; P.I.L. culture, originally from barley meal, Berks., Aug., 1959 ; in culture at P.I.L. since 1957, originally from home-grown (H.G.) wheat on farm, Lancashire, Aug., 1959 ; in domestic supply of rolled oats, Slough, Bucks., Aug., 1959 ; in H.G. barley, on farm, Aberhill, Wilts., Feb., 1960 ; in provender mill spillage, Burnham, Bucks., May, 1960 ; in animal feeding-stuffs (A.F.S.) Slough, Bucks., July, 1960 ; in pig-meal on farm, Helmshore, Lancs., June, 1960 ; in farm A.F.S. store, Boxgrove, Chichester, Sussex, July, 1960 ; in farm A.F.S. store, Fletching, Sussex, July, 1960 ; in flour-mill warehouse, Belfast, N. Ireland, July, 1960 ; in railway A.F.S. store, Axminster, Somersetshire, July, 1960 ; in farm A.F.S. store (including hypopus), Tenterden, Aug., 1960 ; in railway A.F.S. store, Bideford, Devonshire, Aug., 1960 ; in railway A.F.S. store, Newton Poppleford, Devonshire, Aug., 1960 ; in railway A.F.S. store, Monmouthshire, Sept., 1960 ; in baled hay, farm granary, Beverley, E. Yorks., Sept., 1960 ; in A.F.S. store, Pembroke, S. Wales, Sept., 1960 ; in farm store, Chewton Keynsham, Somersetshire, 1960 ; in farm granary, Marlow, Bucks., Oct., 1960 ; in deep litter of poultry house, Hull, E. Yorks., Oct., 1960 ; in domestic flour stocks, Bourne End, Bucks., Nov., 1960 ; in deep litter of poultry house, Dunstable, Beds., Nov., 1960 ; in farm stored H.G. oats, Haverfordwest, Pembs., Nov., 1960 ; in farm stored H.G. barley, Bridgend, Glam., Nov., 1960 ; in H.G. barley, Soulbury, Bucks., Dec., 1960 ; in deep litter of poultry house, Huntingdonshire, May, 1961 ; in H.G. oats from Isle of Man, on Motor Vessel Rema at Plymouth, June, 1961 ; in spillage of railway A.F.S. store, Holsworthy, June, 1961 ; one hypopus in grain in ship ex Vancouver, Canada, at London, Sept., 1962. In grain feed, Tomkins County, New York State, U.S.A., 1953 ; in stored grain, Corvallis, Oregon, U.S.A., March, 1956 ; in stored A.F.S., Oregon, U.S.A., July, 1956.

In farm granary spillage, Kinangop, Kenya (elevation 8,100 ft.), March, 1962 ; in farm granary, North Kinangop, Kenya (elev. 8,150 ft.), March, 1962 ; in farm granary, Mau Summit, Kenya (elev. 8,650 ft.), March, 1962.

(iii) Pest Infestation Lab. (Slough) collection :

In flour, Slough, Bucks., Oct., 1944 ; in flour, Aylesbury, Jan., 1945 ; provender warehouse, Slough, Bucks., Jan., 1945 ; oats in A.F.S. store, Slough, Bucks., Feb., 1945 ; wheat-germ stocks, Slough, Bucks., March, 1945 ; calf food, Slough, Bucks., March, 1945 ; contaminating mite culture (incl. hypopus), Slough, Bucks., March, 1945 ; flour stocks, Slough, Bucks., May, 1945 ; on cheese, Slough, Bucks., July, 1945 ; on macaroni, Slough, Bucks., Aug., 1945 ; H.G. wheat, Sutton Bonington, Leics., Sept., 1945 ; grain store, Slough, Bucks., Jan., 1946 ; grain store, Slough, Bucks., June, 1946 ; hops store, Stone, Staffs., June, 1946 ; grain store (incl hypopus), Slough, Bucks., June, 1947 ; persicaria seeds, Luton, Beds., June, 1947 ; H. G. wheat, Bucks., 1947 ; on dead ♀ chaffinch, Bucks., April, 1948 ; linseed, Derby, Dec., 1948 ; linseed, mustard seed and clover seed, Bishop Stortford, Herts., Dec., 1948 ; maize, Altrincham, Ches., April, 1949 ; maize sievings, Reading, Berks., June, 1949 ; pearl barley, Pudsey, Yorks., June, 1950 ; in house martins' nest, Newport, I.O.W., 1951 ; H.G. grain, Avonmouth, Somerset, March, 1951 ; kitchen cabinet, Heyton, Lancs., May, 1952 ; Cheshire cheese, Liverpool, Sept., 1953 ; farm granary, Bucks., 1954 ; farm granary, Bucks., 1955 ; in custard powder, England, 1956.

(iv) United States National Museum Collection (in part) Washington.

On stored sea-weed, Los Vilos Coq., Chile, June, 1951 ; on cheese, Green Bay, Wisconsin, U.S.A., Jan., 1954 ; in grain dust, Seattle, Washington State, U.S.A., Jan., 1954 ; in dairy cattle feed, Culpepper County, New York State, U.S.A., June, 1957.

PUBLISHED DESCRIPTIONS ATTRIBUTABLE TO *A. siro* L.

Adult form :

Robin, C. (1860). As *Tyroglyphus siro* Lat.
Michael, A. D. (1903). As *Aleurobius farinae* Koch (ex Degeer & Linn.).
Andre, M. (1933). As *Aleurobius farinae* Linn.
Zachvatkin, A. A. (1941). As *Tyroglyphus farinae* L., form *typica*.
Nesbitt, H. H. J. (1945). As *Acarus siro* L.
Robertson, P. L. (1946). As *Tyroglyphus farinae* (Linn.)
Hughes, A. M. (1948). As *Tyroglyphus farinae* (Linn.)
Knülle, W. (1959). As *Acarus siro* L.
Hughes, A. M. (1961). As *Acarus siro* L.
Knülle, W. (1963). As Mehlmilbe, formen B.

Hypopal form :

Schulze, H. (1924). As *Tyroglyphus farinae* (Linn.), Hypopus I.

Material deposited in National Museums

(i) British Museum (Natural History) :

Nine males, twenty-four females and two hypopi, on eight slides labelled with the same data as on neotype slide, British Museum registration numbers ; 1963.9.19. 18-25. About one hundred and thirty specimens (including hypopi) on nine slides labelled : Cultured 10 yrs. Royal Free Hosp. Medical School, London, July, 1959, Collr. A. M. Hughes, 1963.8.19.26-34. Six males, two females, and pre-adults, on five slides labelled : Lab. culture, P.I.L., Slough, Bucks., U.K., Aug., 1959, Collr. D. A. Griffiths, 1963.8.19.35–39. Two males, two females, on one slide labelled : Residues in old provender mill, Burnham, Bucks., U.K., May, 1960, Collr. D. A. Griffiths, 1963.8.19.40. Five nymphs, on one slide labelled : In spillage, warehouse section, flour mill, Belfast, N. Ireland, U.K., 5.vii.1960, Collr. A. Marshall, 1963.8. 19.41. Three females, on one slide labelled : Compound animal feedingstuffs in warehouse, Slough, Bucks., U.K., July, 1960, Collr. D. A. Griffiths, 1963.8.19.42. Twenty adults, on one slide labelled : Residues in a farm store nr. Chichester, Sussex, U.K., July, 1960, Collr. T. McDonald, 1963.8.19.43. Ten adults, on one slide : Residues in a farm feed-store, Fletching, Sussex, U.K., July, 1960, Collr. T. McDonald, 1963.8.19.44. Ten adults and three hypopi, on two slides : Compound animal feedingstuffs in warehouse, Axminster, U.K., 11.viii.1960, Collr. A. S. C. Smith, 1963.8.19.45-46. Twenty adults, on one slide : Compound animal feedingstuffs in warehouse, Bideford, Devon, U.K., Collr. A. S. C. Smith, 1963.8.19.47. One hypopus: Animal feedingstuffs in farm store, Tenterden, U.K., Aug., 1960, Collr. A. M. Hughes, 1963.8.19.48. Eleven adults, on one slide : Compound animal feedingstuffs in warehouse, Monmouth, Wales, U.K., Collr. D. J. Parry, Sept., 1960, 1963.8.19.49. About ten adults, one slide : Self-raising flour in house, Bourne End, Bucks., U.K., 4.xi.1960, Collr. L. P. Lefkovitch, 1963.8.19.50. Ten adults, on one slide : Compound animal feedingstuffs in warehouse, Pembroke Town, Wales, U.K., Collr. D. J. Parry, 28.ix.1960, 1963.8.19.51. Four adults (*T. longior* also on slide) : Home-grown barley in farm-store, Bridgend, Glam., U.K., Nov., 1960, Collr. D. J. Parry, 1963.8.19.52. Three males, two females, on one slide : Home-grown barley in grain store, Soulbury, Bucks., Dec., 1960, Collr. R. W. Howe, 1963.8.19.53. Four females, four males, on two slides : Animal feedingstuffs residues, warehouse, Holsworthy, U.K., June, 1961, Collr. A. S. C. Smith, 1963.8.19.54-55. About one hundred specimens, on one slide : Chicken battery house, Farnham Royal, Bucks., U.K., October, 1962, Collr. G. E. Woodroffe, 1963.8.19.56. About fifty specimens, on one slide : Bagged oat-chaff, provender mill., London, U.K., Collr. E. M. Bland, 1963.8.19.57. Eight specimens, on one slide : Grain residues in flour mill bin, Dumfriesshire, U.K., Collr. J. M. Baynes, 21.vi.1963, 1963.8.19.58. Twelve specimens, on one slide : Barley meal on barn floor, Boxford, Berks., U.K., 2.vii.1963, Collr. N. Hunter, 1963.8.19.59. Twelve specimens, one one slide : Spillage near grinder, Westbrook farm, Berks., U.K., 3.vii.1963, Collr. N. Hunter, 1963.8.19.60. Six specimens, on one slide : Meal spillage, provender mill, Henley, Berks., U.K., 4.vii.1963, Collr. N. Hunter, 1963.8.19.61. Twenty-two specimens, on one slide : Mouldy wheat residues, Manor farm, Tetsworth, Oxon., U.K., 18.vii.1963, Collr. N. Hunter, 1963.8.19.62. One male, three females and one nymph, on two slides : Residues, farm granary, North Kinangop, Kenya, Elev. 8,150 ft., March, 1962, Collr. C. W. Coombs, 1963.8.19.63-64. One female : Residues, farm granary, Mau summit, Kenya, Elev. 8,650 ft., March 1962, Collr. C. W. Coombs, 1963.8.19.65. Sixteen specimens, on one slide : In stored feed, Corvallis, Oregon, U.S.A., March 21, 1956, Collr. G. W. Krantz, 1963.8.19.66.

(ii) United States National Museum, Washington :

Three males, ten females, on three slides with the same data as the neotype specimen. Two males, two females and two hypopi, on six slides : Cultured 10 yrs. Royal Free Hosp. Medical School, London, July, 1959, Collr. A. M. Hughes. Seven adults, on one slide : Residues in farm store nr. Chichester, Sussex, U.K., July, 1960, Collr. T. McDonald. Eighteen specimens, on one slide : Residues in farm feed-store, Fletching, Sussex, U.K., July, 1960, Collr. T. McDonald. Five hypopi, on one slide : Compound animal feedingstuffs, in warehouse, Axminster, U.K., 11.viii.1960, Collr. A. S. C. Smith. Five adults, on one slide : Compound animal feedingstuffs, in warehouse, Pembroke Town, Wales, 28.ix.1960, Collr. D. J. Parry. Two males, on one slide : Home-grown barley in store, Soulbury, Bucks., U.K., Dec., 1960, Collr. R. W. Howe. Four males, on one slide : Animal feedingstuffs residues, warehouse, Holsworthy, U.K., June, 1961, Collr. A. S. C. Smith. One female : Residues, farm granary, North Kinangop, Kenya, Elev. 8,150 ft., March, 1962, Collr. C. W. Coombs.

Male and female on same slide : Residues, farm granary, Mau summit, Kenya, Elev. 8,650 ft., March 1962, Collr. C. W. Coombs.

Acarus immobilis sp. n.

Adult, Tritonymph, Protonymph and Larva. (Text-figs. 24, 25). Morphology of all stages except the hypopus closely resembles the corresponding stages of *A. farris*. I have been unable to detect any diagnostic differences in colour, shape, body size, or setation of the body.

A multivariate discriminant analysis, using four associated measurements was employed on two populations of *A. immobilis* and one of *A. farris* in an attempt to separate the adults of the two species. The following measurements were made on a total of sixty-three male specimens :

a = body length
b = length of $omega_1$ on tarsus I
c = length of $omega_1$ on tarsus II
d = length of tarsus IV

The measurements were selected from many others of different parts of the body as being the most likely to give a separation suitable for use as a diagnostic character. Text-fig. 23, a graphic presentation of the results of this analysis,

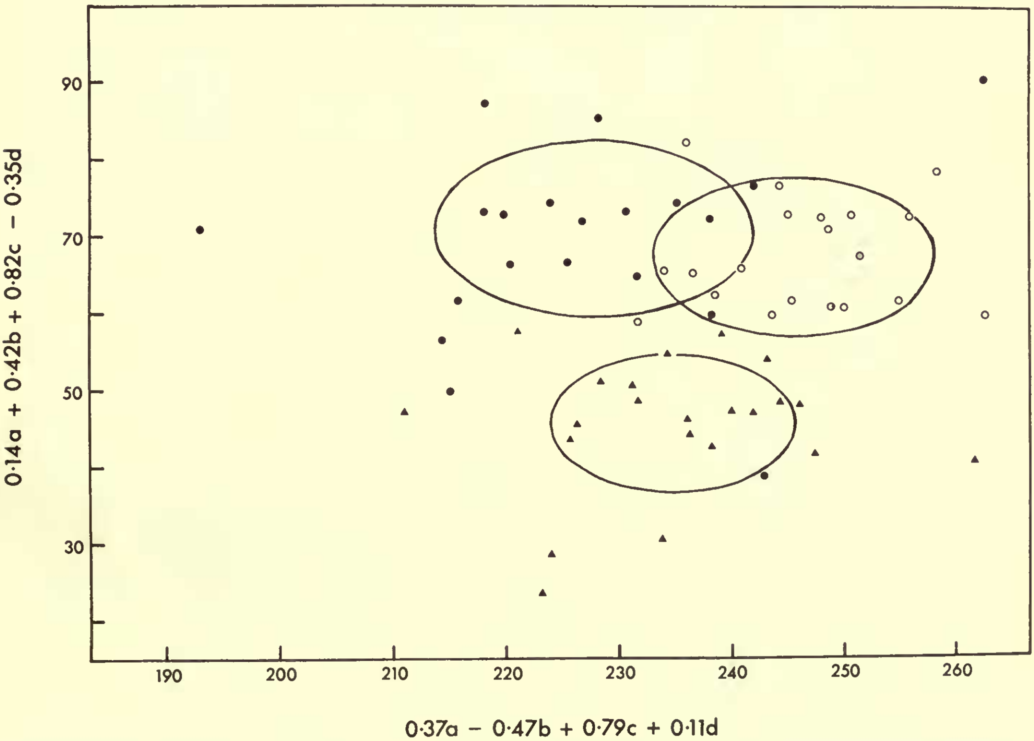
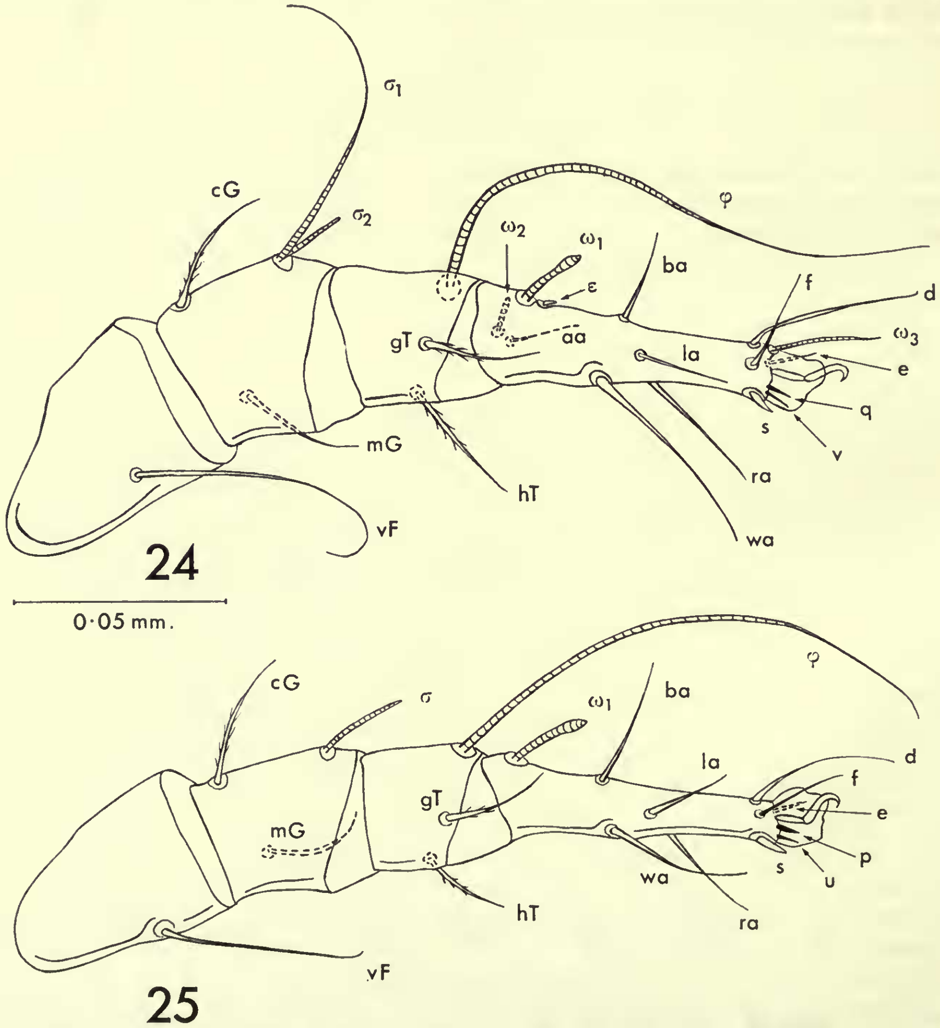


Fig. 23. Diagram illustrating the maximum discrimination possible in two dimensions, based on four measurements upon twenty-one individuals from each of two *A. immobilis* populations and one *A. farris* population.

shows the maximum variation which can be obtained. Although the populations can be seen to be different, over-lap between the species occurs to an extent which precludes the separation of the two species on this basis.

The length of setae on dorsal surface of idiosoma when expressed as a percentage of idiosomal length are indistinguishable from those of *A. farris*. Chaetotaxy of the legs of all stages, except the hypopus, is the same as that for the corresponding stages of *A. farris*. Text-figs. 24 and 25 (legs I and II of the female) demonstrate that the length and shape of setae and solenidia are also very similar to those on specimens of *A. farris*, except for a difference in the shape of omega$_1$ on tarsus I and II of the adults. This difference is more noticeable on the female and, providing a



FIGS. 24–25. *Acarus immobilis* sp. n. ♀ paratype, leg chaetotaxy. Fig. 24, leg I—preaxial face. Fig. 25, leg II—preaxial face.

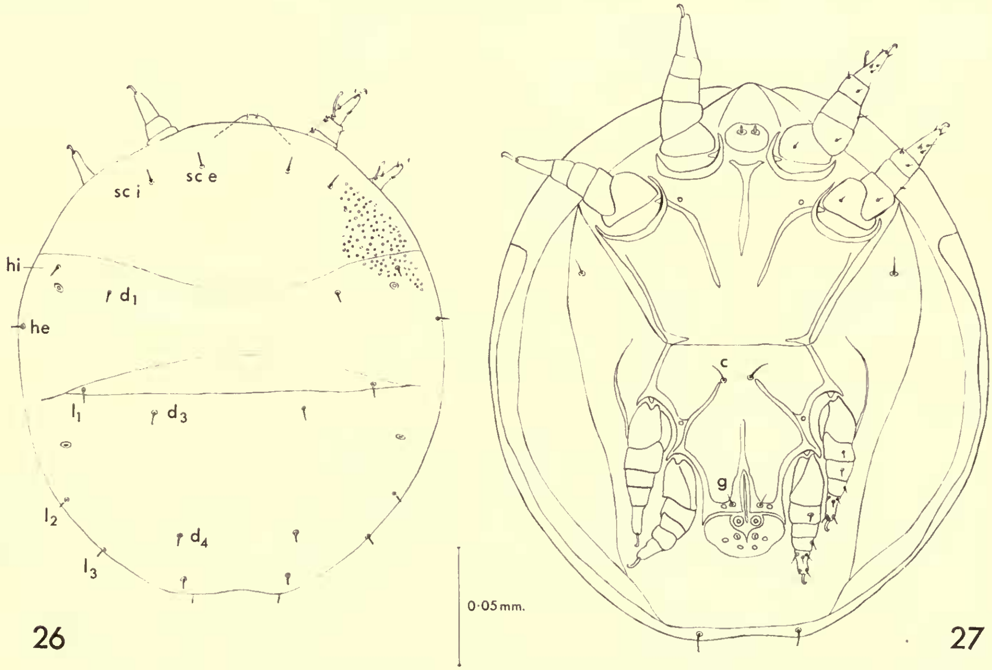
true lateral view is obtained, it is a reliable diagnostic character. In lateral view the sides of the stem of omega$_1$ are virtually parallel, expanding into a distinct egg-shaped terminal head (Plate 1, fig. 4).

The adult forms may be distinguished from *A. siro* employing the same characters which separate *A. siro* and *A. farris*, although spine s of *A. immobilis* appears to be very slightly larger than corresponding spine s of *A. farris*.

HYPOPUS (Text-figs. 26, 27). The hypopus which is an inert kind has been described by Schulze (1923), Zachvatkin (1941) and Hughes (1955; 1961) under the names *Tyroglyphus farinae* or *Acarus siro*. Phase-contrast microscopy has enabled me to observe certain minute setae on the body and legs which could not have been resolved by the microscopes used by these authors. Consequently, the hypopus stage is re-described below.

Body length : average of 20 specimens = 0.21 mm.

Referred to as the inert hypopal form since the legs are capable of feeble movements only and are unable to support the body, although almost all individuals eventually escape from the protonymphal skin.



26 27

FIGS. 26–27. *Acarus immobilis* sp. n., hypopus paratypes, Fig. 26, dorsum. Fig. 27, venter.

When viewed from the dorsal surface (Text-fig. 26) the idiosoma is roundly oval, posterior margin rounded or often slightly concave and anterior margin pointed. Surface convex covered with very shallow punctations irregular in size and distribution. Idiosoma divided into a distinct propodosoma and hysterosoma. Eyes not present.

Chaetotaxy of dorsal surface very similar to motile forms except setae v e, d_2 and one pair on posterior margin of hysterosoma are absent. All setae are very short and extremely difficult to see. Hysterosoma bears a pair of circular pores, one behind each of the h i setae and a pair of glands on lateral margin of body on a level with coxae IV.

On ventral surface (Text-fig. 27) the coxal skeleton is well developed, but extremely difficult to follow ; bears close resemblance to coxal skeleton of motile *Acarus* hypopi, being more like *A. siro* in that apodemes IV are almost straight and not bow-shaped as in *A. farris*.

Gnathosoma very much reduced, represented by a hemi-spherical protrusion (situated between coxae I) which bears a pair of very small protuberances each terminating in a short blunt process.

Setae h v present, plus one pair coxal setae above distal ends of epimeres IV and a pair of genital setae either side of anal slit. Two pairs circles in corners of coxal fields I and IV are presumably vestigial coxal suckers.

Sucker plate much reduced, wider than long ; latero-posterior margins indented. Only anterior pair of peripheral suckers are developed, central pair and remaining two pairs of peripherals and pair on either side of genital setae are vestigial.

The leg chaetotaxy of the inert hypopus of *A. immobilis* is much reduced compared with that found on the motile hypopal forms of *A. farris* and *A. siro*. The formula for setae and solenidia of the legs (see Text-figs. 28, 29, 30, 31) is as follows :

Leg I	II	III	IV
(7.2.2.1.1)	(5.2.2.1.1)	(7.1.1.0.1)	(7.1.0.1.0)
	Solenidia (famulus absent)		
(1.1.1.0.0)	(1.1.0.0.0)	(0.1.0.0.0)	(0.1.0.0.0)

On leg I, solenidion $omega_2$, seta e and the ventral spine complex are absent ; $omega_1$ is almost as long as the tarsus, bearing a distinct egg-shaped terminal expansion. Sigma and psi are very short and blunt.

On leg II, setae e, f, aa, ventral spine complex and sigma are absent ; $omega_1$ is again almost length of tarsus.

Chaetotaxy of legs III and IV is the same as for the motile forms except seta e is not present. Psi on these two legs is short and pointed.

Thus, the chaetotaxy of the legs of this inert hypopus is not so very different from that of the motile forms. The major difference is that all the setae of the inert form are spine-like and very much reduced in size. With the exception of $omega_1$, the solenidia are also much smaller. Tarsal claws are well developed.

DISTRIBUTION. England, Scotland, Germany, U.S.A. (possibly France, Italy, Egypt).

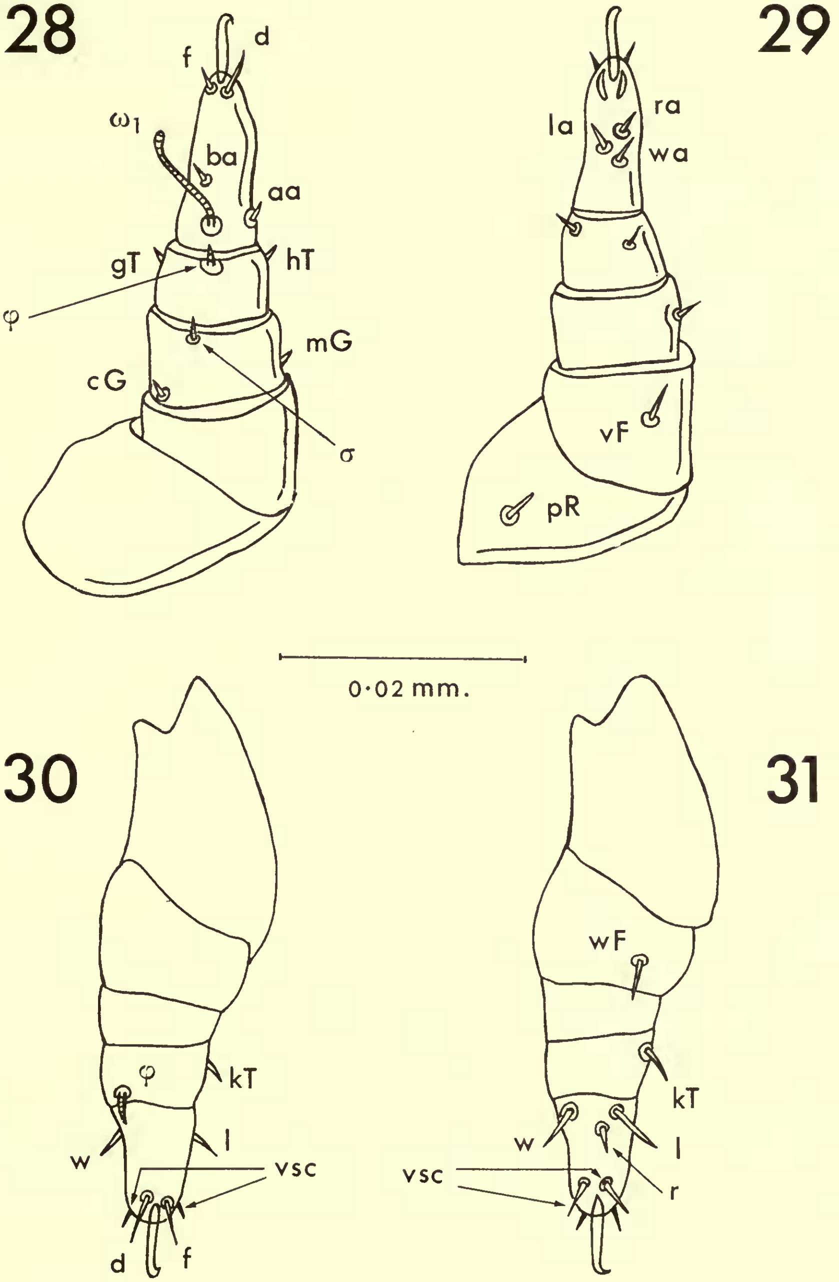
HABITAT AND LOCALITY.

(i) A. C. Oudemans' collection, Leiden :

On a hyacinth bulb, Sassenheim, Feb. 1924.

(ii) D. A. Griffiths' collection :

On imported Northern Manitoba wheat (hypopus), stored at Avonmouth, Sept., 1953 ; in straw at base of crated New Zealand cheese (hypopus), stored at Chatham, Sept., 1953 ; in mouldy grain residues of farm store, (hypopus) Nassington, North-



FIGS. 28–31. *Acarus immobilis* sp. n., hypopus leg chaetotaxy. Figs. 28–29, right leg I dorsum and venter, respectively. Figs. 30–31, dorsum and venter of right leg IV.

ants., July, 1960 ; in sparrow's nest (including hypopus), nesting box 3, Kinloch farm, Island of Rhum, Scotland, Nov., 1960 ; in hay loft of same farm, July, 1962 ; in H.G. oats, from Isle of Man, on M.V. Rema at Plymouth (including hypopus), June, 1961 ; in grain residues (including hypopus) on M.V. Beavercove, at Victoria Docks, London, May, 1961.

(iii) Pest Infestation Lab. (Slough) collection :

In pigeon's nest, Brentford, Middx., Nov., 1950 ; in grain residues beneath floor of grain silo, Aldershot, Hants., Oct., 1956.

(iv) United States National Museum collection, Washington :

In potato cellar, Arco, Idaho, 17.v.1951 ; on dahlia from Babylon, imported into New York, 31.vi.1934 ; in soil and various plants from Italy, imported into Boston, 1955 ; on potatoes from Egypt, imported into Boston, 1956 ; on *Ginko biloba* from France imported into Washington, 1957.

MISIDENTIFICATIONS ATTRIBUTABLE TO *A. immobilis* sp.n.

Adult form :

Canestrini, G. (1888). As *Aleurobius farinae* Degeer.

Hypopal form :

Schulze, H. (1924). As *Tyroglyphus farinae* (L.) Hypopus II.
Zachvatkin, A. A. (1941). As *Tyroglyphus farinae* (L.)
Hughes, A. M. (1955). As *Acarus siro* L.
Türk, E. & Türk, F. (1957). As *Tyroglyphus farinae* (L.)
Hughes, T. E. (1959). As *Acarus siro* L.
Hughes, A. M. (1961). As *Acarus siro* L.

Material deposited in National Museums

(i) British Museum (Natural History) :

HOLOTYPE : Male : Sparrow's nest, box 3, Kinloch Farm, Isle of Rhum, U.K., Collr. P. Wormell, Nov., 1960, 1963.8.19.67, mounted in Berlese fluid.

PARATYPES : Five males, twelve females and hypopi, on nineteen slides, with same data as holotype, 1963.8.19.68-86.

OTHER MATERIAL : Two males, two females and hypopi, on six slides : Grain residues, Meadow view farm, Nassington, Northants., U.K., July, 1960, Collr. D. A. Griffiths, 1963.8.19.87-92. One female : In straw beneath imported New Zealand cheese, at Chatham, Kent, U.K., Collr. R. W. Howroyd, Sept., 1953, 1963.8.19.93.

(ii) United States National Museum (Washington) :

PARATYPES : Three males, six females and hypopi, on eleven slides, with same data as holotype slide.

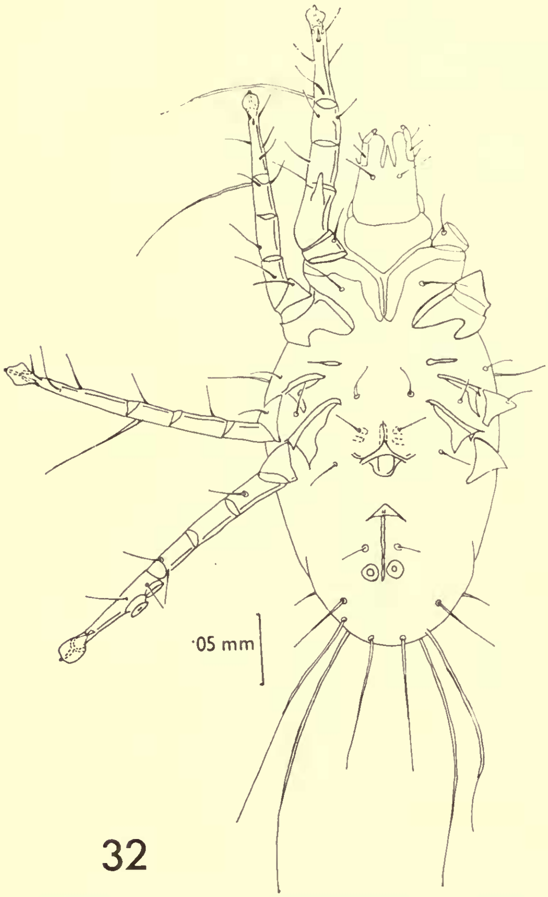
OTHER MATERIAL : One male, two females and hypopi, on five slides : Grain residues, Meadow view farm, Nassington, Northants., U.K., July, 1960, Collr. D. A. Griffiths.

Acarus gracilis Hughes, 1957

Type : *Acarus gracilis* Hughes, A. M. (1957). *Ann. Mag. Nat. Hist.* **10** : 753–761, figs.

This species differs from the three species of the *A. siro* complex as follows :

MALE (Text-figs. 32, 33). Scapular setae short, about twelve to fifteen per cent of idiosomal length. Setae d_1, d_3, d_4, h i, h v, l a, l p, and sa e shorter than or about equal in length to scapulars ; d_2 more than four times longer than other dorsals. Sa i long, about seventy per cent of idiosomal length. On tarsus IV copulatory suckers are large, fleshy and close together at the base of the segment.



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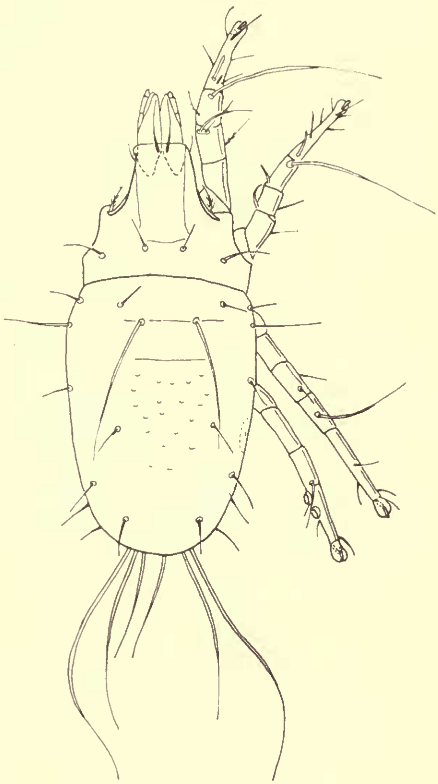

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FIGS. 32–33. *Acarus gracilis* Hughes ♂. Fig. 32 venter. Fig. 33, dorsum. Re-drawn from original drawings by A. M. Hughes.

FEMALE (Text-fig. 34 ; Pl. I, fig. 3). Idiosomal setae lengths as for male except that d_3 are longer, more than twice as long as d_1.

In length of setae of anal region it resembles *A. farris* and *A. immobilis* but pa_1 are longer here ; differs from *A. siro* in that a_3 are not more than twice length of a_1 or a_2.

The chaetotaxy of the legs of the adult is very similar to that of the other species except for the shape of $omega_1$. Solenidion $omega_1$ gradually tapers from base to apex, and there is virtually no terminal expansion (Pl. I, fig. 3).

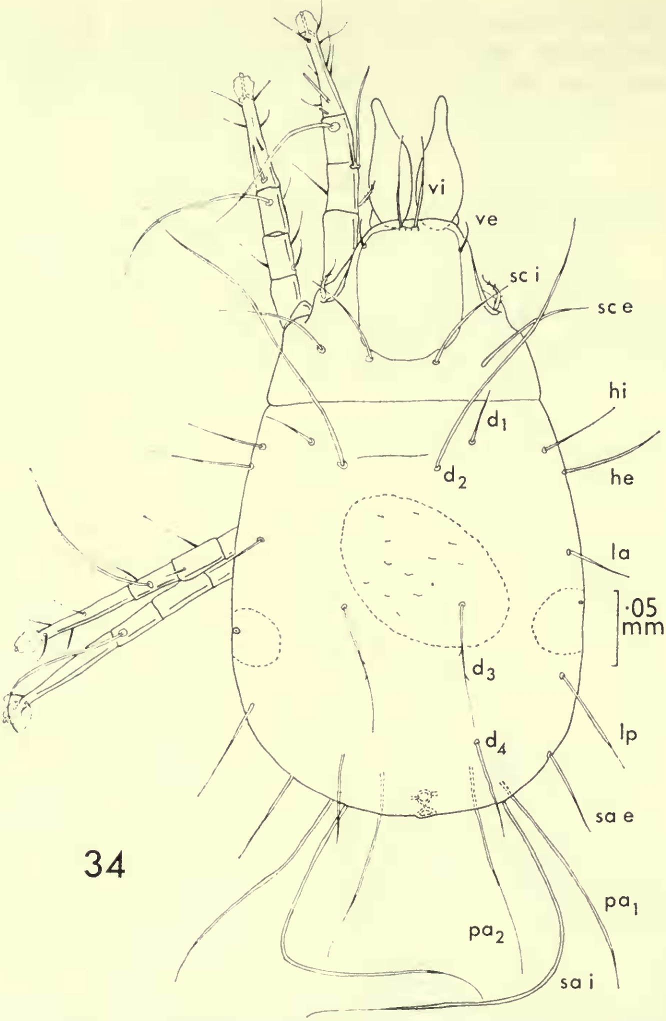


FIG. 34. *Acarus gracilis* Hughes ♀, dorsum. Re-drawn from original drawing by A. M. Hughes.

HYPOPUS (Text-figs. 35, 36, 37, 38 & 39). Is inert in form, closely resembles hypopal form of *A. immobilis* but the following characters are different.

Central pair of suckers are the largest pair on sucker plate ; they are well developed, not vestigial as in *A. immobilis*. Pair of setae on ventral posterior margin of hysterosoma are as long as combined length of tibia IV plus tarsus IV. Coxal skeleton not well developed.

CHAETOTACTIC FORMULAE FOR SETAE AND SOLENIDIA OF THE LEGS :

Leg I	II	III	IV
(7.0.0.0.0)	(6.0.0.0.0)	(8.1.1.0.0)	(8.1.0.0.0)
Solenidia (famulus absent)			
(1.1.1.0.0)	(1.1.0.0.0)	(0.1.0.0.0)	(0.1.0.0.0)

If these formulae are compared with those given for *A. immobilis*, it will be seen that the same solenidia are present in both species but the number of setae on leg segments tibia to trochanter is much less in *A. gracilis*.

The shape and lengths of setae and solenidia (Text-figs. 36–39) are also different from those of *A. immobilis*. Omega$_1$ is short, being not longer than psi of the genu ; many of the tarsal setae are as long or longer than the respective tarsi and often leaf-like in shape. Seta e is present on tarsus III and IV.

DISTRIBUTION. Known from S.E. England only.

HABITAT AND LOCALITY.

(i) Pest Infestation Lab. (Slough) collection:

In bat dung and straw in the attic of a house, near Basingstoke, Hants., October

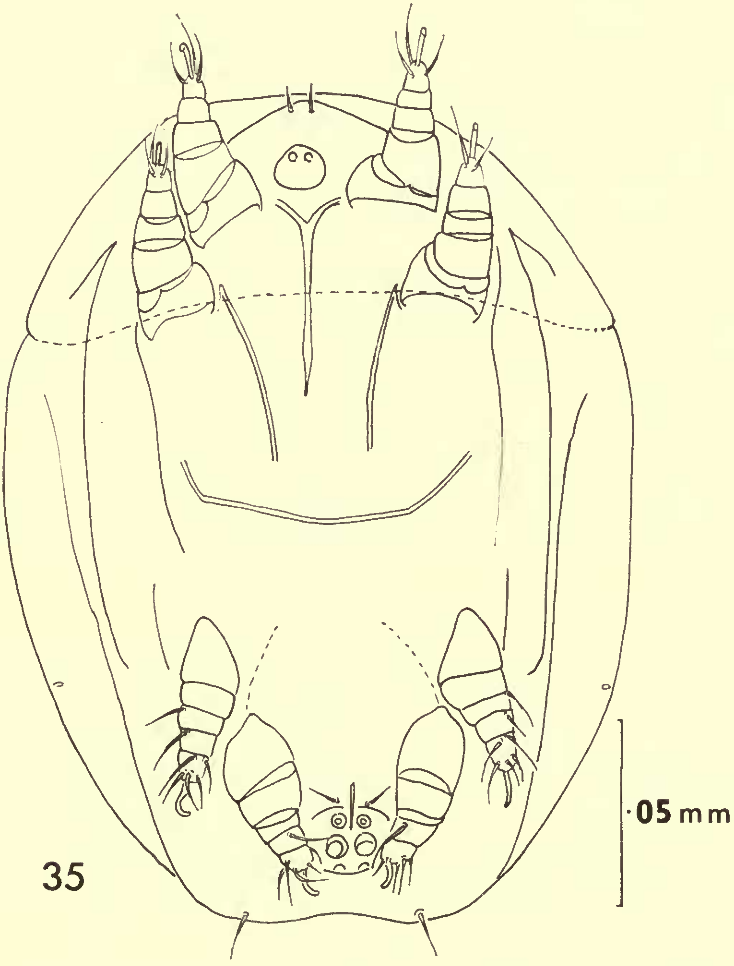
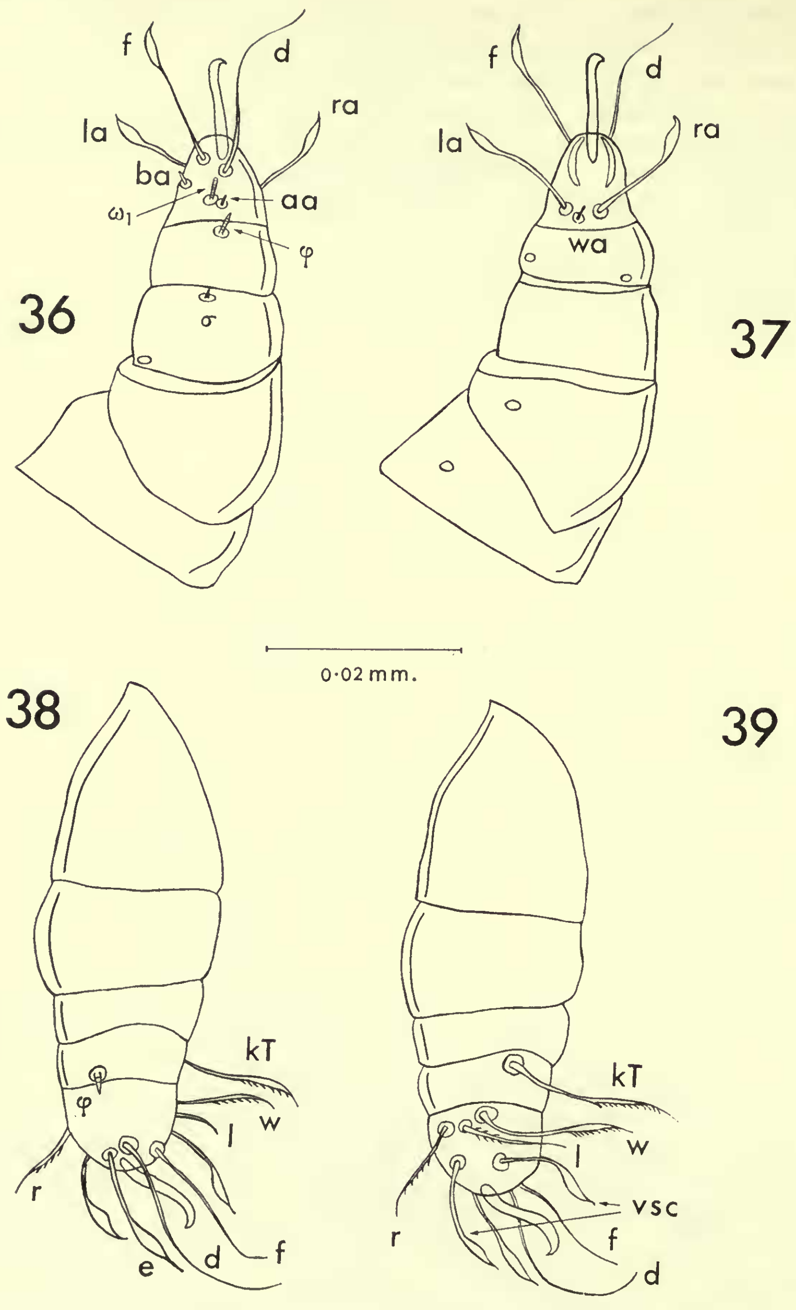


FIG. 35. *Acarus gracilis* Hughes hypopus, ventral view. Re-drawn from original drawing by A. M. Hughes.



FIGS. 36–39. *Acarus gracilis* Hughes hypopus, leg chaetotaxy. Figs. 36–37, leg I dorsum and venter, respectively. Figs. 38–39, leg IV dorsum and venter, respectively.

1954 ; in a bat-roost inside a house, Slough, Bucks., July, 1955 ; in old grain debris in attic and first floor of farm granary, Datchet, Bucks., Dec., 1955 ; in residues beneath floor of wheat intake section, flour-mill, Aldershot, Oct., 1956 ; in a bat-roost in a stone tower, Bramshill, Hants., Nov., 1956.

(ii) D. A. Griffiths' collection :

From bird's nest and old nest residues beneath the original tiled roof of a 17th century farmhouse (bats and rats also in residence) near Cumnor, Berks., Sept., 1961.

Acarus tyrophagoides (Zachvatkin, 1941) **comb. n.**

Type : *Tyroglyphus tyrophagoides* Zachvatkin, A. A. (1941). Faune de l'U.R.S.S. Arachnoidea **6** No. 1 : 1–475, figs. *Inst. Zool. Acad. Sc.* Moscow, N.S. No. 28.

The major differences between *A. tyrophagoides* and all other species described above are based on Zachvatkin's original description. Figures 40, 41 and 42 are re-drawn from Zachvatkin (1941).

Scapular setae sc e 1·8 to 3·2 times longer than sc i. Of the hysterosomal setae on the dorsal surface only d_1. d_2, h i and l a are short, from four to thirteen per cent of isiosomal length, whereas all other setae are long, from forty to seventy-five per cent of idiosoma (Text-fig. 40). Thus, in life, adults bear a superficial resemblance to species of the genus *Tyrophagus*. Setae d_3 and d_4 are very long, being about six times longer than d_1 or d_2 (Text-fig. 40).

When viewed laterally, tarsus I of the male bears a swelling on the ventral surface in the region of setae r a and l a (Text-fig. 41).

The supra-coxal setae are long, gently curved and sparsely pectinate (Text-fig. 42).

The hypopus has not been described.

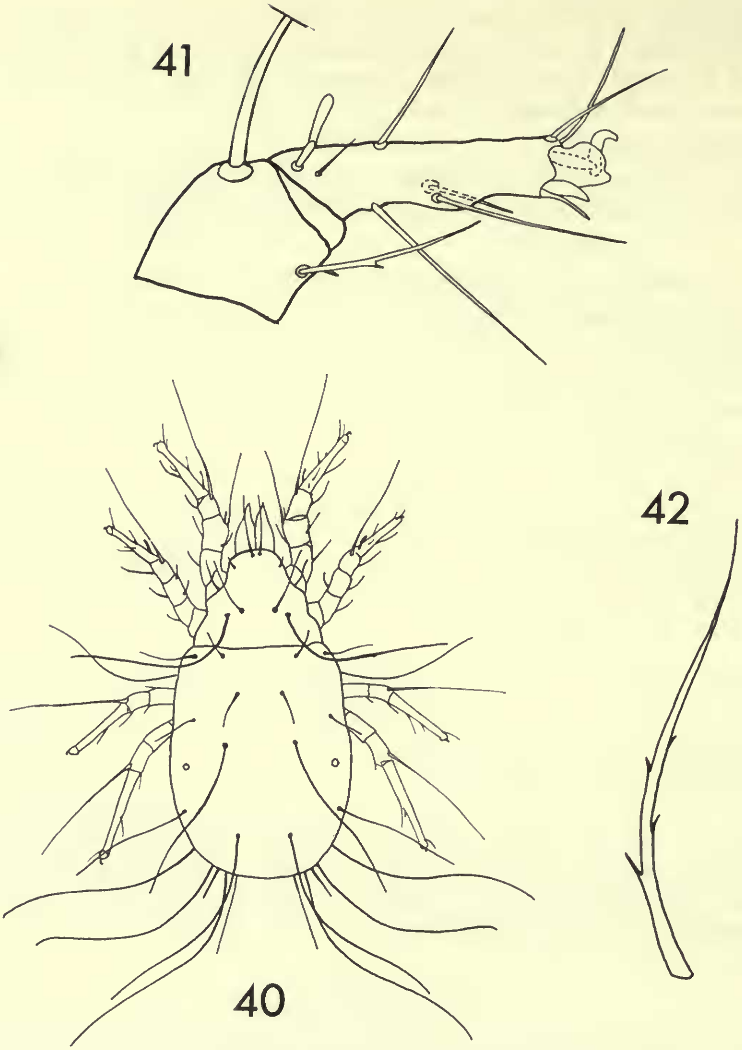
Distribution, Habitat and Locality. This species has been found in Russia only. Zachvatkin (1941) reported that it was taken from the surface layer of soil near a government grain store in the Tartar region. Also from the dead leaf litter of a deciduous forest in the Odessa region. Vysotskaya (1961) found it in the nest of a small mammal (Insectivore) Russia, 1953.

Specimens *incertae sedis*

Virtually all the material of this genus, which has been examined in the past, came from Europe and possibly North America. I have been able to examine small amounts of material which originated, or is believed to have originated, from other parts of the world. The origin of some of the specimens is uncertain because they were collected from produce imported into the U.S.A. or Britain. A small number of these specimens cannot be assigned with certainty to any one of the five species already described. It is considered wiser, at this stage, to list them as specimens *incertae sedis*, although some may be worthy of specific rank. They are catalogued below according to country of origin of the material from which they were taken.

Brazil

$Omega_1$ on tarsus I and II closely resembles that of *A. farris*, but some setae of idiosoma are much longer, especially v i and dorsals. Setae d_2, d_3 and d_4 of this



Figs. 40–42. *Acarus tyrophagoides* (Zach.). Fig. 40, ♀ dorsum. Fig. 41, ♂ tarsus and tibia I—postaxial face. Fig. 43, supra-coxal seta. Re-drawn from Zachvatkin (1941).

specimen all measure more than twenty per cent of the idiosoma. Corresponding setae on *A. farris* specimens are less than ten per cent of idiosomal length.[1]

Material consists of one slide, United States National Museum, Washington. On the left hand label, written in pencil, is :— *Tyroglyphus farinae* Degeer. Right hand label, in black ink is :— On orange navel end, Brazil : At Boston, 8.5.40, Beauchamp ; Boston no. 16017. Lot 40– 18488 (U.S.N.M. number).

[1] Photomicrographs of solenidion sigma$_1$ and histograms illustrating relative lengths of idiosomal setae for all the specimens *incertae sedis* are given in Griffiths (1963) Ph.D. thesis, London University, unpublished.

There are three specimens on the slide ; the centre specimen is *not* an *Acarus*, specimens on left and right are an *Acarus* female and male respectively.

Presumably, these were taken from a cargo discharged at Boston, therefore, cross infestation may have occurred.

New Zealand

Omega$_1$ is very similar in shape but longer than that of *A. immobilis*. Also, all setae of idiosoma except v e are longer, although body length of these specimens are about the same as specimens of *A. immobilis*.

Material, preserved in Oudeman's fluid, was given to me by Dr. A. M. Hughes. It was originally collected from straw beneath New Zealand cheese stored in the London area, July, 1953. The straw presumably originated in this country. The sample also contained inert hypopi identical with those of *A. immobilis*. I have measured the relevant hysterosomal setae of a male and female which Dr. Hughes reared from these hypopi. The setal measurements of this male, when expressed as a percentage of the idiosomal length, closely resembles those obtained from other populations of *A. immobilis*. Measurements made on New Zealand males show that their idiosomal setae are longer, almost ten per cent in some cases. Also, setae sc i are longer than sc e, whereas the opposite is true for *A. immobilis* specimens.

The above evidence suggests that the long setae adults termed " New Zealand " did not give rise to, nor emerge from, the inert hypopi which were found in their company. It may be that *A. immobilis* under different nutritional conditions will be found to have setal lengths which vary to an extent which could include the New Zealand specimens. But, until such information is available, I prefer to consider these long setae adults as specimens *incertae sedis*.

Formosa

The shape of omega$_1$ and relative lengths of the idiosomal setae is extremely similar to the New Zealand specimens. The extra length of the dorsal setae of the Formosan specimens can be accounted for by the fact that the dorsal setae of females tend to be a little longer than those of males.

Data : One slide U.S. National Museum, registration number 56–12672.

Left label : *Tyrophag.* [in pencil]. Right : On *Citrus grandis* fruit, Formosa ; at Phila ; Pa. Oct. 8, 1956, J. Freedland, Collr. Lot 56–12672.

There are two females on the slide ; one still partly enclosed within the tritonymphal skin. Other mites, not *Acarus* or *Tyrophagus*, also on slide.

Japan

Omega$_1$ similar to that of *A. tyrophagoides*. Setae on dorsal surface of idiosoma, except v e and v i, are long, without pectinations and with fine whip-like endings. The train of setae extending behind the opisthosoma bears a superficial resemblance to that of *A. tyrophagoides*. Material differs from *A. tyrophagoides* in that sc i are too long and d_3, d_4 and sa i too short ; no swelling on ventral surface of male tarsus I.

This is possibly a new species, but a description based on two specimens is not considered desirable at this stage.

Data : One slide U.S. National Museum, number 40.21938.

Left label : *Tyroglyphus farinae* Deg. [In pencil]. Right : On *Citrus* sp. Japan : at Seattle, Washington, Oct. 10, 1940, Seattle number 9081 [Black ink].

Azores

Known from one female only. Shape of $omega_1$ and shape and size of spine s is extremely similar to *A. siro*. However, setal histogram is different ; d_2 is the longest of the dorsal setae, being three times longer than d_1 and about equal in length to the scapular setae. This specimen is discussed in the section below.

Data : One female, U.S. National Museum slide number 56–3596.

Left label : *Tyrophag.* [In pencil]. Right : in, on, around Dasheens, Azores : at New York, Jan. 20, 1956, T. V. Henneberry, Collr. Lot 56–3596 [Black Ink].

Kenya

Known from one female, in my collection. $Omega_1$ and spine s as for Azores female and therefore similar to *A. siro*. However, setal pattern extremely like Azores female and therefore different from *A. siro* specimens.

This specimen was collected by my colleague C. W. Coombs, in grain residues of a farm granary, Kenya, April 1962. *A. siro* specimens were taken from the same material.

The Azores ♀ was taken from dasheens, which are a form of sweet-potato. Thus, both the Azores and Kenya specimens were found in a stored-product habitat. Their close resemblance to *A. siro* suggests that they may possibly be a variation of this species.

China

$Omega_1$ fairly short, expanding gradually into a distinct terminal club, the tip of which is more round than pointed. Seta d_2 longest of dorsals ; about twice length of d_1. Spine s strong, about two thirds length of tarsal claw but width at base only a quarter of length.

Data : One slide U.S. National Museum, number 37–2183. One male, one female and a female not of *Acarus* on slide.

Left label : *Tyroglyphus farinae* De G. Right : On waterchestnuts, China ; at Chicago, Col. by H. W. Hooker, Jan. 22, 1937.

New Mexico

Known from six slides U.S. National Museum, (only one of which bears a registration number) representing material collected near Santa Fé from two separate but similar habitats, namely, the nests of two small mammals *Perognathus flavus* and *Dipodomys spectabilis*.

The *P. flavus* nest material (36 specimens on one slide) is made up of very small mites with short tarsi. Material from the *D. spectabilis* nest (17 adults on 5 slides) is made up of twelve mites with short cylindrical tarsi as found in the *P. flavus* nest and five adults in which the tarsi are much longer, tapering towards the extremity. Length of the idiosomal setae of these two forms are different in that mites with long tarsi also have longer scapular, dorsal and lateral setae, especially d_3, d_4 and l_p. Since it has been shown (Griffiths, 1963, Ph.D. unpub.) that tarsal length and shape can be influenced by varying the nutritional value of the food given to pre-adult stages, it is considered that these forms probably represent intraspecific variation.

The following characters serve to distinguish these specimens from all others described above. Omega$_1$ long ; from a narrow base it expands gently until, just before the tip, it swells out into a large rounded terminal club. Anal suckers of male minute, their periphery being indistinct. Chelicerae sharply pointed, with sharp, well-defined teeth.

Data : One slide, left label :— *Acarus siro*. Right label : —in *Perognathus flavus* nest, Santa Fé, New Mexico ; Feb. 29, 1952 ; H. B. Morlan Collr., No. 416. Lot 52–1181 (U.S. National Museum Registration Number). Nineteen males and seventeen females.

Five slides ; numbered 806 to 810 inclusive. All labels as follows :— Left label : *Acarus siro*. Right label : Santa Fé, New Mexico, 2 Feb., 1953 ; ex *Dipodomys spectabilis* nest 63A. H. B. Morlan. Total 8 ♂♂ and 9 ♀♀s.

4. ECOLOGY OF *ACARUS*

Published ecological data for the flour mite *A. siro* L., 1758, indicate that this species successfully occupies a wide variety of natural habitats as well as being a serious pest of stored food (Zachvatkin, 1941 ; Sorokin, 1951 ; Woodroffe, 1953 ; Robertson, 1955 ; Griffiths, 1960 ; Boczeck, 1961). An analysis (Appendix II) of the habitat records taken from the text of this paper suggests that this published information is misleading.

For example, from Appendix II, the records for the species making up the *A. siro* complex can be expressed thus :

	No. of times *A. siro* complex recorded	% occurrence of each species		
		A. siro	*A. farris*	*A. immobilis*
Stored product environment	93	76·3%	16·1%	7·5%
Out-door habitat	27	11·1%	59·3%	29·6%

The frequency with which each species occurred in one or other of the two environments is :

Species	Total No. of pops. recorded	% of pops. in stored product habitat	% of pops. in out-door habitat
A. siro	74	95·9%	4·1%
A. farris	31	48·4%	51·6%
A. immobilis	15	46·6%	53·4%

There are, therefore, grounds for suggesting that many of the published records of the occurrence of *A. siro* in natural habitats may be based on misidentifications of *A. farris* and *A. immobilis*.

Within the stored product environment, micro-habitat differences separating *A. siro* from *A. farris* and *A. immobilis* show up very clearly when the stored product habitat is sub-divided as follows :—

	No. of times *A. siro* complex recorded	% occurrence of each species		
		A. siro	*A. farris*	*A. immobilis*
Processed cereal products*	35	100 %	0	0
Cereals as whole grains, also hay in farm-stores	38	57·9%	26·3%	15·8%

* Sometimes combined with non-cereal materials.

Ten of the ninety-three populations recorded from stored produce contained two or more species of the *A. siro* complex : *A. siro* and *A. farris* occurred together eight times, *A. farris* and *A. immobilis* once and all three species once. With one exception (deep litter in a poultry house) the infested material was unprocessed cereals. Populations from out-door habitats were each of one species only. Therefore, whole cereals—a natural link between the warehouse and out-door habitats—appear to be the chief zone of hybridization between the three species of the *A. siro* complex.

It seems probable from the above evidence that *A. farris* and *A. immobilis* are out-door species which are often transported, via the farm to storage premises, in parcels of home-grown cereals. Once they have reached the farm granary or warehouse, there seems to be some barrier which prevents them from becoming established in processed cereal products. A possible explanation may lie in the nutritional differences between processed cereals and the food available in natural habitats ; in this connection the occurrence of *A. farris* on cheese (Appendix II) also requires further investigation.

A. siro appears to be the dominant species within the stored product habitat. Unlike the two field species it seems to be capable of living on processed cereals as well as whole grains. Little can be said about the *A. siro* populations taken from out-door habitats (three records as compared with 16 for *A. farris* and eight for *A. immobilis*). These may have originated in food stores and travelled via the farm to the field. It is equally possible that they represent indigenous populations, since *A. siro* must originally have been confined to natural habitats. Further investigations must be made to determine, as far as possible, the distribution and status (indigenous, or secondary) of these field populations.

The motile hypopal form of *A. siro* has been recorded frequently in ecological papers, mainly from out-door habitats. This paper shows that the hypopus of *A. siro* has been described once only (Schulze, 1924) and that the hypopus of *A. farris* has been attributed incorrectly to *A. siro* in no less than six published descriptions of recent years. Further, the habitat records show that fifty-eight per cent of the *A. farris* populations contained hypopi, whereas the figure for *A. siro* was only 6·75 per cent. It is suggested, therefore, that many of the published records concerning the distribution and frequency of occurrence of the *A. siro* hypopus are based on misidentifications of *A. farris*.

The suggestions put forward in the above paragraphs are based on a limited number of records verified by the author. However, the evidence is sufficient to cast a reasonable doubt upon the correctness of results obtained from past surveys of the " Flour mite " and to justify new ecological studies within and outside food storage premises.

A. gracilis, which produces an inert hypopus, has been recorded from south-east England only. The few records available indicate that it is closely associated with bat-roosts (see page 451).

A. tyrophagoides is known from Russia only. It appears to be an out-door species but the authentic records (see page 453) are too few to provide a basis for any speculation as to its micro-habitats.

5. SUMMARY

A neotype is designated for *Acarus siro* [var.] *farinae* L., 1758.

Five species taxa are recognised, one of which was hitherto erroneously placed in synonymy ; another is described for the first time. Keys to five adult and four hypopal forms are provided.

The " Flour mite " represents a complex of three species, namely ; *A. siro* L., 1758, *A. farris* (Ouds., 1905) and *A. immobilis* sp. n.

The hypopi attributed to " *Acarus siro* " are re-described and associated with their correct adult form.

The ecology of the species is reviewed.

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APPENDIX I

A list of the names appearing in published works which have been considered in the course of this revision.

Bold type is used to indicate the original description of the valid names of the species recognised in this paper.

Most descriptions have been allocated to a genus. The generic name is given in square brackets at the end of the reference. Descriptions which cannot be assigned to a genus are indicated thus [n.a.].

A description allocated to the genus *Acarus* L., 1758 is also assigned to a species when this is possible.

(i) Adult form :

Acarus siro farinae Linnaeus, 1758, *Syst. Nat.* (ed. 10) **reformata 1** : 615.

Acarus siro farinae L., 1758, sensu Fabricius, 1775, *Systemae Entomologie* : 813 . [n.a.]

Käsemilbe, Schrank, 1776. *Beytrag. Naturg.* : 121, tab 6, figs. 2, 3 . . [*Acarus* sp.]

Mitte (sic) de la farine Degeer, 1778. *Mem. pour servir à l'hist. des insectes,* **7** : 97, pl. 5, fig. 15 . . . . [*Acarus* sp.]

Mitte domestique Degeer, 1778. *Mem. pour servir à l'hist. des insectes*, **7** : 88, pl. 5, figs. 2, 3, 4 . . . . [*Glycyphagus*]
Acarus siro Schrank, 1781, in *Augustae Vindelicorum* : 514, pl. 3, fig. 4 . . [*Carpoglyphus*]
Acarus siro L., 1758, sensu Fabricius 1781, *Species Insectorum Exhibientes*, **2** : 489 [*Acarus* sp.]
Acarus siro L., 1758, sensu Fabricius 1794, *Ent. Syst.* **4** : 430 . . . [*Acarus* sp.]
Acarus siro Linn. Fab. sensu Latreille, 1796, *Précis des carac. gén. des Insectes* etc. : 185 [n.a.]
Acarus siro Linn. sensu Latreille, 1802, Sonnini's ed. *Suites à Buffon*, **7** : 63 . . [n.a.]
Acarus siro sensu Fabricius, 1805, *Syst. Antliat.* : 357 . . . . [*Glycyphagus*]
Acarus domesticus sensu Latreille, 1806, *Gen. Crust. Ins.*, **1** : 150 . . . [*Glycyphagus*]
Acarus farinae sensu Latreille, 1806, *Gen. Crust. Ins.*, **1** : 151 . . . . . [n.a.]
Acarus siro Fab., sensu Latreille, 1810, *Consid. Gen. Anim. Crust. Ins.* : 132 & 425 [n.a.]
Acarus siro sensu Fabricius, 1822, *Syst. Antliat.* (ed. 2) : 357 . . . [*Glycyphagus*]
Acarus farinae Degeer sensu Dugés, 1834, *Ann. Sci. Nat.* **2** : 37 . . . . [n.a.]
Acare (sic) domestique Degeer sensu Dugés, 1834, *Ann. Sci. Nat.* **2** : 37 . . [*Acarus* sp.]
Acarus farinae sensu Sundeval, 1837, *Physiogr. Sällsk. Tidskr.* **1** : 35, figs. 10, 11, 12 [*Acarus* sp.]
Acarus farinae Degeer, sensu Koch 1841, in Panzer *Deuts. Ins.*, Heft 32, 21 . [*Acarus* sp.]
Acarus siro Linn. sensu Koch, 1841, in Panzer *Deuts. Ins.*, Heft 32, 24 . . [*Glycyphagus*]
Acarus siro sensu Sundeval, 1842, *Isis* **35,** fasc. 6 : 445, pl. 2, figs. 10, 12 . [*Glycyphagus*]
Acarus farinae Degeer sensu Gervais, 1844, *Walk. Hist. nat. Ins. Apts.* **3** : 262 . [n.a.]
Tyroglyphus siro (Tyroglyphe domestique) Linn. Degeer sensu Gervais, 1844, *Walk. Hist. nat. Ins. Apts.* **3** : 261, pl. 35, fig. 4 . . . . [n.a.]
Acarus siro Van Leeuwen, 1846, *Nederl. Lancet*, ser. 2, **1,** fasc. 11 : 661, pl. 11, fig. 6 [*Acarus* sp.]
Tyroglyphus siro Lat. sensu Robin, 1860, *Mem. Soc. Nat. Moscou*, **33** : 233, pl. 5, fig. 5, pl. 8 . . . . [*Acarus siro* L.]
Acarus siro Linn. sensu Canestrini & Fanzago, 1877, *Atti. Ist. Veneto.* **4,** (5) : 69 [*Tyrophagus*?]
Tyroglyphus siro Lat. sensu Mégnin, 1880, *Les Parasites et les maladies parasitaires* : 142, fig. 48 . . . . [*Acarus* sp.]
Tyroglyphus farinae (D.G.) Gerv. sensu Berlese, 1884, *Acari, Myriopoda et Scorpiones* etc., Fasc. 14, No. 9, one pl. . . . . [*A. farris*]
Aleurobius farinae Degeer sensu Canestrini, 1888, *Pros. dell' Acar. Ital.*, **3** : 399, pl. 30, fig. 1 . . . . [*A. immobilis*]
Tyroglyphus siro Linn. sensu Canestrini, 1888, *Pros. dell' Acar. Ital.*, **3** : 402, pl. 31, fig. 2 [*Tyrophagus*]
Acarus siro Linn. sensu Oudemans, 1897, *Tijdschr. Ent.*, **40** : 261 . . . [*Tyrophagus*]
Tyroglyphus siro (L.) em. Latr. sensu Canestrini & Kramer, 1899, in *Das Tierreich*, Leif 7 : 141 . . . . [*Tyrophagus?*]
Acarus siro L. sensu Oudemans, 1901, *Tijdschr. Ned. Dierk.*, **1** : 86 . . [*Tyrophagus*]
Tyroglyphus siro (L.) def. by Gerv. sensu Michael, 1903, *British Tyroglyphidae*, **2** : 117, pl. 36, in Ray. Soc. Publ. London . . . . [*Tyrophagus*]
Aleurobius farinae Koch (ex Degeer & Linn.) sensu Michael, 1903, *British Tyroglyphidae*, **2** : 73, pl. 29 . . . . [*Acarus siro*]
Aleurobius farinae (L.) sensu Oudemans, 1905, *Ent. Ber. Amst.*, **1** : 19 . . [*Acarus siro*]
Aleurobius farris Oudemans, 1905, *Ent. Ber. Amst.*, **1** : 20 . . . . [*Acarus farris*]
Aleurobius farinae var. *africana* Oudemans, 1906, *Ent. Ber. Amst.*, **2** : 43 . [*Acarus siro*]
Tyroglyphus casei Oudemans, 1910, *Ent. Ber. Amst.*, **3** : 74 . . . . [*Tyrophagus*]
Tyroglyphus farris Ouds. 1905 sensu Oudemans, 1913, *Arch. Naturgesch.*, **79,** (10) : 45 [*Acarus farris*]
Acarus siro L. sensu Oudemans, 1913, *Arch. Naturgesch.*, **79,** (10) : 53 . . [*Sarcoptes*]
Tyroglyphus farinae L. sensu Oudemans, 1913, *Arch. Naturgesch.*, **79**, (10) : 61 [*Acarus siro*]
Aleurobius farinae (Degeer) sensu Newstead & Duval, 1918, *Rep. Grain Pests Comm. Roy. Soc.* No. **2** : 6, text-fig. a . . . . [*Acarus farris*]

Aleurobius farinae (Degeer) sensu Newstead & Morris, 1920, *Rep. Grain Pests Comm. Roy. Soc.* No. 8 : 11, pl. 6, figs. 27, 28 . . . . [*Acarus* sp.]
Tyroglyphus farinae (Linné, 1758) sensu Vitzthum, 1929, *Acari*, in *Die Tierwelt Mitteleuropas*, **3** : 73 . . . . [*Acarus* sp.]
Acarus siro (Linné, 1758) sensu Vitzthum, 1929, *Acari*, in *Die Tierwelt Mitteleuropas*, **3** : 88 . . . . [*Sarcoptes*]
Aleurobius farinae (Linn.) sensu André, 1933, *Ann. Epiphyt.*, **19** : 355, 3 figs. [*Acarus siro*]
Tyroglyphus siro L. sensu Jary & Stapley, *Jl. S.E. Agric. Coll.*, **40** : 119 . . [*Tyrophagus*]
Tyroglyphus farinae L. form *typica* sensu Zachvatkin, 1941, *Faune de l'U.R.S.S.* **6** : 86, figs. 91, 113, *Inst. Zool. Acad. Sci. Moscow* . . . . [*Acarus siro*]
Tyroglyphus farinae L. form *farris* sensu Zachvatkin, 1941, *Faune de l'U.R.S.S.*, **6** : 90, figs. 118–120, *Inst. Zool. Acad. Sci. Moscow* . . . . [*Acarus farris*]
Tyroglyphus tyrophagoides Zachvatkin, 1941, *Faune de l'U.R.S.S.*, Arachnoidea **6** No. 1 : 90, figs. 107–111, *Inst. Zool. Acad. Sci. Moscow* . . . . [*Acarus tyrophagoides*]
Acarus siro (Linn.) sensu Nesbitt, 1945, *Canad. J. Res.* (D), 23 : 139, fig. 6 . [*Acarus siro*]
Tyroglyphus farinae (Linn.) sensu Robertson, 1946, *Trans. Proc. Roy. Soc. N.Z.*, **76** : 185, fig. 11 . . . . [*Acarus siro*]
Tyroglyphus farinae (Linn.) sensu Hughes, 1948, *Mites Assoc. with Food Prods. H.M.S.O.* London : 16, fig. 8 . . . . [*Acarus siro*]
Acarus gracilis Hughes, 1957, *Ann. Mag. Nat. Hist.*, **10** : 753, figs. 1, 2, 6, 7, 9, 10
Tyroglyphus farinae (L., 1758) sensu Türk, E. & Türk, F., 1957, *Beitr. Syst. Okol.*, **1**, (1) : 63, figs. 3, 4 . . . . [*Acarus* sp.]
Acarus siro L., 1758, sensu Knülle, 1959, *Mitt. Zool. Mus. Berl.*, **32** : 347, figs. 1, 23 [*Acarus siro*]
Acarus siro (Linn.) sensu Hughes, T. E., 1959, *Mites or the Acari*, London, pl. 7, fig. 2 [*Acarus* sp.]
Acarus siro (Linn.) sensu Hughes, A. M., 1961, *Tech. Bull. No. 9.*, *H.M.S.O.* London : 287, figs. 8, 9 . . . . [*Acarus siro*]
Acarus siro L., form A, sensu Knülle 1963, *Naturwissenschaften* **5** : 1 . . [*A. farris*]
Acarus siro L., form B, sensu Knülle 1963, *Naturwissenschaften* **5** : 1 . . . [*A. siro*]

(ii) The hypopus form:

Tyroglyphus farinae Degeer, sensu Canestrini, 1888, *Pros. dell' Acar. Ital.*, **3** : 399 . [n.a.]
Tyroglyphus longior Gervais sensu Michael, 1903, *British Tyroglyphidae* **2** : 123, pl. 39, figs. 1–4, Ray. Soc. Publ. . . . . [*Acarus farris*]
Aleurobius farinae L. sensu Oudemans, 1905, *Tyjdser Ned. Dierk.*, **8** : 207, pl. 8, figs. 14, 15 [*Acarus farris*]
Tyroglyphus dimidiatus (Herm.) sensu Oudemans, 1905, *Ent. Ber. Amst.*, **1** : 223 [*Acarus farris*]
Aleurobius farinae (Degeer) sensu Newstead & Duval, 1918, *Rep. Grain Pests Comm., Roy. Soc.* No. 2 : 7 . . . . [*Acarus* sp.]
Tyroglyphus longior Gervais sensu Newstead & Morris, 1920, *Rep. Grain Pests Comm., Roy. Soc.* No. 8, pl. 6, fig. 30 . . . . [*Acarus* sp.]
Tyroglyphus farinae (Linn.) sensu Schulze, 1924, *Zbl. Bakt.*, **60** : 536, figs. 1–11 . . [Hypopus I = *A. siro* ; hypopus II = *A. immobilis*]
Aleurobius farinae Koch sensu Jary, 1936, *Ann. Mag. Nat. Hist.*, **10** : 546, fig. [*Acarus farris*]
Tyrophagus dimidiatus (Herm.) sensu Oboussier, 1939, *Z. angew. Ent.*, **26** : 253, fig. 10 [*Acarus farris*]
Tyroglyphus farinae (L.) sensu Zachvatkin, 1941, *Faune de l'U.R.S.S.*, Arachnoidea **6** No. 1 : 86, figs. 67–69 & 57, 58 [Migratory hypopus = *Acarus farris;* resting hypopus = *Acarus immobilis*]
Tyroglyphus farinae (Linn.) sensu Hughes, A. M., 1948, *Mites Assoc. with Stored Food Prods.*, *H.M.S.O.*, London : 16, figs. 12, 13 . . . . [*Acarus farris*]
Acarus siro (L.) sensu Hughes, A. M., 1955, *Ent. Mon. Mag.*, **91** : 99, figs. 1, 2, 3 . . [*Acarus immobilis*]

Tyroglyphus farinae (L., 1758) sensu Türk, E. & Türk, F., 1957, *Beitr. Syst. Okol.*, **1** : 63, figs. 5, 6 . . . . [Wandernymphe = *Acarus farris*]
[Dauernymphe = *Acarus immobilis*]

Acarus siro L. 1758 sensu Knülle, 1959, *Mitt. Zool. Mus. Berl.*, **32** : 347, figs. 27–29 . . [*Acarus farris*]

Acarus siro L. sensu Hughes, T. E., 1959, *Mites or the Acari*, London, pl. 10, figs. 1, 2, 3
[motile hypopus = *Acarus farris*]
[inert hypopus = *Acarus immobilis*]

Acarus siro L. sensu Hughes, A. M., 1961, *Tech. Bull. No.* 9, *H.M.S.O.*, London : 27, figs. 20, 23, 28 . . . . . . [Active hypopus = *Acarus farris*]
[Inert hypopus = *Acarus immobilis*]

APPENDIX II

Analysis of the habitat records which appear in the text under the descriptions of British *Acarus* species. Specimens from all populations were verified by the author.

The habitat (location and kind of material)	Number of populations recorded						
	Single species populations				Mixed species populations		
1. THE STORED PRODUCT HABITAT	*A. siro* L.	*A. farris* (Ouds.)	*A. immobilis* sp. n.	*A. gracilis* Hughes	*A. siro* and *A. farris*	*A. farris* and *A. immobilis*	All three species of *A. siro* complex
(a) Materials not stored on farms							
Cereals	12	3	4	1*	3	–	1
Compound animal feeding-stuffs	14	–	–	–	–	–	–
Flour	5	–	–	–	–	–	–
Other household cereal prods.	11	–	–	–	–	–	–
Cheese	2	4	1	–	–	–	–
Non-food prods.	3	–	–	–	–	–	–
Seeds	3	–	–	–	–	–	–
Laboratory cultures (contaminants)	3	–	–	–	–	–	–
(b) Materials stored on farms							
Home grown cereals	8	5	1	–	4	1	–
Compound animal feeding-stuffs	5	–	–	–	–	–	–
Hay	2	2	1	–	–	–	–
Deep litter poultry houses	3	1	–	–	1	–	–
TOTAL	71	15	7	1	8	1	1
2. OUT-DOOR HABITATS							
(a) Associated with animals							
Mammal's nests	–	2	–	–	–	–	–
Bird's nests	1	3	2	–	–	–	–
On mammals or birds	2	1	–	–	–	–	–
Bat roosts and/or attics	–	–	–	5	–	–	–
(b) Other habitats							
In soil ; on plants ; bulbs ; fruit	–	8	6	–	–	–	–
As hypopi on insects	–	2	–	–	–	–	–
TOTAL	3	16	8	5	–	–	
GRAND TOTAL	74	31	15	6	8	1	1

* Taken from grain residues beneath floor of grain intake section of a flour-mill.